Series 1956, No. 14

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# SOIL SURVEY

# Southwest Quay Area New Mexico

OUR SOIL ★ OUR STRENGTH

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with
NEW MEXICO AGRICULTURAL EXPERIMENT STATION

# HOW TO USE THE SOIL SURVEY REPORT

THIS SOIL SURVEY of the Southwest Quay Area will serve several groups of readers. It will help farmers and livestock men in planning the kind of management that will protect their soils and provide good yields; assist engineers in selecting sites for roads, buildings, and other structures; and add to the soil scientist's fund of knowledge.

In making this survey, soil scientists dug holes and examined surface soils and subsoils; measured slopes with a hand level; noticed differences in the growth of crops, weeds, and grasses; and, in fact, recorded all the things that they thought might affect the suitability of the soils for farming, livestock production, engineering, and related uses.

The scientists plotted the boundaries of the soils on aerial photographs. Then, cartographers prepared the detailed soil map shown in the back of this report. Cultivated fields, roads, creeks, and other landmarks are shown on this map.

## Locating soils

Use the index to map sheets to locate areas on the large map. The index is a small map of the survey area on which numbered rectangles have been drawn to show where each sheet of the large map is located. When you find the correct sheet of the large map, note that the boundaries of the soils are outlined and that there is a symbol for each kind of soil. All areas marked with the same symbol are the same kind of soil, wherever they appear on the map. The symbol will be inside the area if there is enough room; otherwise, it will be outside the area and a pointer will show where the symbol belongs. Suppose, for example, you find an area on your farm or ranch marked with the symbol Pe. The legend for the detailed map shows that this symbol identifies Pullman loam, 0 to 2 percent slopes. This soil and all other mapped in the county are described in the section, Descriptions of Soils.

## Finding information

Few readers will be interested in all parts of the soil survey report, for it has special sections for different groups, as well as some sections of value to all. The section, General Nature of the Area, points out outstanding features of the survey area and will be of interest mainly to those not familiar with the Southwest Quay Area.

*Farmers and those who work with farmers* will be interested mainly in the sections, Soil Associations, Descriptions of Soils, and Use and Management of Soils. A study of these sections will aid them in identifying soils on a farm, in learning ways the soils can be managed, and in judging what yields can be expected.

*Engineers* will want to refer to the section, Engineering Applications. The tables in this section show characteristics and qualities of the soils that affect engineering.

*Soil scientists* will find information about how the soils were formed and how they were classified in the section, Formation and Classification of Soils.

*Students, teachers, and other users* will find information about soils and their management in various parts of the report, depending on their particular interest.

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# Contents

Series 1956, No. 14 Issued May 1960

# SOIL SURVEY OF SOUTHWEST QUAY AREA, NEW MEXICO

SURVEY BY W. A. BUCHANAN, IN CHARGE, AND W. J. DAVIS, J. A. HUGHES, AND WARREN JOHNSON, SOIL CONSERVATION SERVICE

REPORT BY W. A. BUCHANAN

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UNITED STATES DEPARTMENT OF AGRICULTURE IN COOPERATION WITH THE NEW MEXICO AGRICULTURAL EXPERIMENT STATION

THIS is a survey of all the soils in the southwestern part of Quay County. It comprises the area lying above and south of the caprock escarpment. It also includes two areas below the escarpment, one a tract of about 40 square miles in the southwestern corner, and the other, a smaller area to the north. The survey area is bordered on the west by Guadalupe and De Baca Counties, on the south by De Baca and Roosevelt Counties, and on the southeast by Curry County; the caprock escarpment marks the northern boundary (fig. 1). The area surveyed covers approximately 479,953 acres, or about 750 square miles.

This soil survey is part of the technical assistance furnished by the Soil Conservation Service to the Southwest Quay Soil Conservation District. Fieldwork for the survey was finished in 1956. Unless otherwise specified, all statements in the report refer to conditions in the county at the time fieldwork was in progress.

## *Soil Associations*

The soils of this survey area have been placed in seven soil associations, or broad soil areas, as shown on the colored map in the back of this report. Each association has a distinct pattern of soils in which the soils of one or two series are dominant. The soils dominant in the pattern are shown in the name of the association.

A map of soil associations is useful to those who want to compare different parts of a county; to those who want to locate large areas suitable for some particular kind of agriculture or other broad land use; or to those who need to suggest a program of management for large areas of land.

### Association 1

Deep and moderately deep, medium-textured hardland (*Pullman*, *Amarillo*, *and Pullman-Mansker loams*).—This association of soils is the most extensive in the survey area. The soils have a loamy surface layer and a compact, moderately fine textured subsoil. In some places the depth to strongly calcareous material is more than 48 inches, but in others it is between 20 and 36 inches. Small spots that are calcareous to the surface are common in some areas.

The slopes are smooth, and the relief is nearly level to gently undulating. Most of the slopes are slightly less than 1 percent. In a few areas there are slopes of as much as 5 percent.

The soils of this association are among the most productive in the survey area. Dryland winter wheat is

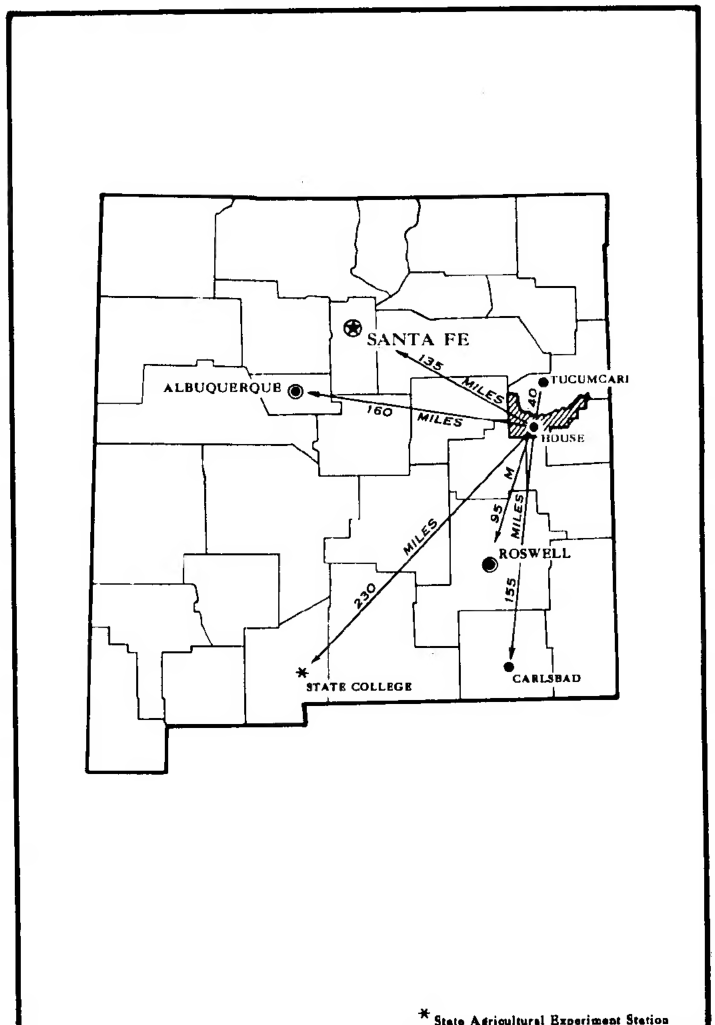


*Figure 1.*—Location of the Southwest Quay Area in New Mexico.

the principal cash crop, but rye, barley, and grain sorghums are also grown. Because the climate is semiarid, farmers cannot rely on continuous high yields under dryland farming. The soils respond well to irrigation. If they are adequately irrigated and fertilized, high yields of crops can be obtained.

Many small areas of native pasture occur throughout this association. These areas range in size from a few acres to several sections; the larger ones are in the western part of the survey area.

## Association 2

Deep and moderately deep, moderately sandy land (*Clovis-Amarillo and Springer fine sandy loams*).—This association is made up of the moderately sandy row-crop soils. It is confined largely to the south-central part of the survey area. In most places the depth to soft caliche is more than 48 inches; in some places it ranges from 20 to 36 inches, or averages about 28 inches.

The slopes are smooth, and the relief is nearly level to undulating. Most of the slopes are less than 1 percent, but some are slightly more than 5 percent.

The soils of this association are used mainly for row crops grown under dryland farming. The principal crops are grain sorghums, sudangrass, and winter wheat. There are small areas of native pasture throughout this association. When precipitation is limited, better dryland yields of crops can be produced on these soils than on the finer textured hardland soils of Association 1.

If the soils are properly irrigated and fertilized, high yields of crops are obtained. The yields are somewhat lower, however, than those obtained on the soils of Association 1. The soils are highly susceptible to soil blowing and must be protected properly.

## Association 3

Very shallow to moderately deep, medium-textured, strongly calcareous soils (*Potter and Mansker loams*).—This association of soils occurs throughout the survey area, primarily along drainageways and playas. In general, the areas are on side slopes and on the upper margins of slopes. Some areas are within broad, nearly level areas of deep, noncalcareous soils.

Most of the areas remain in native pasture. If properly managed, they provide good grazing. Only small areas next to areas of deeper soils are cultivated. Under dryland farming the Mansker soils are fairly productive, but they do not respond to irrigation so well as the deeper, noncalcareous loamy soils. If cultivated, soils of this association are highly susceptible to soil blowing and considerable care must be taken to prevent damage.

## Association 4

Calcareous sandy soils (*Arch and Drake fine sandy loams*).—In this association are gray, shallow, calcareous soils that generally range in texture from loamy sand to sandy loam. In a few places the texture is loam. Most of this association occurs along Alamosa Creek, near House. North of this area there is a smaller area. The relief ranges from nearly level, along Alamosa Creek, to dunelike, on the east side of the playa 1.

The soils of this association are low in natural fertility. Most of the association is in native grasses, which provide fair to good forage.

## Association 5

Valley slopes and breaks (*Ima and La Lande soils and Stony rough land*).—This inextensive association occurs along the caprock in the western part of the survey area. Stony rough land, consisting of a mixture of caliche, shale, and sandstone, lies along the caprock. On the valley slopes below the breaks of the caprock are the Ima and La Lande soils. The Ima soils, which were formed from recent alluvial wash, are deep, medium textured, and immature. Little development of a soil profile is evident. The La Lande soils, which were also formed from alluvial materials, are deep and medium textured and have a moderately developed to well developed profile.

The areas of this association are used only for grass. Good forage is produced, but not in the quantity obtained on the more nearly level areas. In places sheet and gully erosion are common.

## Association 6

Tobosa flats (*Montoya and Regnier soils*).—This inextensive association is made up mainly of deep Montoya clays and clay loams that occur in the northwestern corner of the survey area and along Truchas Creek. The areas are subject to overflow during periods of heavy rainfall. The Regnier soils are shallow silt loams.

The areas lie below the caprock in the western part of the survey. They are dry and are used only for native pasture. Although the soils contain some soluble salts, a heavy growth of galleta and alkali sacaton is produced. Except along stream drainageways, erosion is slight.

## Association 7

Mixed hardland and Solonetzic soils (*Manwood-Pullman loams*).—The soils of this association are medium textured and are 16 to 40 inches deep over the underlying caliche. The areas are in the northwestern part of the survey area and are characterized by many scab, or slick, spots. These scab spots have a low to moderate amount of exchangeable sodium and produce little or no vegetation. They make up about 5 percent of the association.

Except in the scab spots, this association produces fair to good native pasture. If a cover of grass is maintained, erosion is not a problem. Some areas have been farmed and later abandoned.

# *Descriptions of Soils*

The soil scientists who prepared this survey went over the area at appropriate intervals and examined the soils by digging with a spade, auger, or power soil sampler. They examined the different layers, or horizons, in each boring, and they compared the different borings. By

such comparisons, they determined the different kinds of soils in the area.

Then, they described the various soils and drew boundaries on aerial photographs to separate them. The soils are described in the following pages. Their acreage and proportionate extent are shown in table 1, and their location can be seen on the detailed map at the back of this report.

The soil series (groups of soils) and the single soils (mapping units) are described in alphabetic order.

An important part of each series description is the soil profile, a record of what the soil scientist saw and learned when he dug into the ground. It is to be assumed that all soils of one series have essentially the same kind of profile. The differences, if any, are explained in the description of the soil or are indicated in the soil name. To illustrate, a detailed profile is described for the Mansker series, and the reader is to conclude that all soils in the Mansker series have essentially this kind of profile.

Following the name of each soil, there is a set of symbols in parentheses. These identify the soil on the detailed map. The climatic zone and capability grouping, as well as range site, are given for each mapping unit. The capability units and range sites are described in the section, Use and Management of Soils.

In describing the soils, the scientist frequently assigns a letter symbol, for example "$A_1$", to the various layers. These letter symbols have special meanings that concern scientists and others who desire to make a special study of soils. Most readers will need to remember only that all letter symbols beginning with "A" are surface soil; those beginning with "B" are subsoil; and those beginning with "C" are substratum, or parent material.

The boundaries between horizons are described so as to indicate their width and shape. The terms for width are (1) *abrupt*, if less than 1 inch wide; (2) *clear*, if about 1 to 2½ inches wide; (3) *gradual*, if 2½ to 5 inches wide; and (4) *diffuse*, if more than 5 inches wide. The shape of the boundary is described as *smooth*, *wavy*, *irregular*, or *broken*.

The color of a soil can be described in words, such as "yellowish brown," or can be indicated by symbols for

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

| Soil | Acres | Percent |
|---|---|---|
| Alama loam, 0 to 2 percent slopes | 100 | [1] |
| Alama loam, 2 to 5 percent slopes | 370 | 0.1 |
| Alama silt loam, 0 to 2 percent slopes | 719 | .1 |
| Alama silt loam, 2 to 5 percent slopes | 1,170 | .2 |
| Amarillo loam, 0 to 2 percent slopes | 13,392 | 2.8 |
| Amarillo loam, 2 to 5 percent slopes | 4,234 | .9 |
| Amarillo loam, valleys, 0 to 2 percent slopes | 1,420 | .3 |
| Amarillo loam, valleys, 2 to 5 percent slopes | 390 | .1 |
| Amarillo fine sandy loam, 0 to 2 percent slopes | 8,568 | 1.8 |
| Amarillo fine sandy loam, 2 to 5 percent slopes | 2,664 | .6 |
| Arch loam | 1,477 | .3 |
| Arch fine sandy loam | 2,256 | .5 |
| Arch loamy fine sand | 800 | .2 |
| Arvana loam, shallow, 0 to 2 percent slopes | 6,968 | 1.5 |
| Arvana loam, shallow, 2 to 5 percent slopes | 2,043 | .4 |
| Arvana fine sandy loam, shallow, 0 to 2 percent slopes | 178 | [1] |
| Arvana fine sandy loam, shallow, 2 to 5 percent slopes | 278 | .1 |
| Church clay loam | 2,077 | .4 |
| Clovis-Amarillo loams, 0 to 2 percent slopes | 13,547 | 2.8 |
| Clovis-Amarillo loams, 2 to 5 percent slopes | 3,607 | .8 |
| Clovis-Amarillo loams, valleys, 0 to 2 percent slopes | 170 | [1] |
| Clovis-Amarillo loams, valleys, 2 to 5 percent slopes | 530 | .1 |
| Clovis-Amarillo fine sandy loams, 0 to 5 percent slopes | 2,467 | .5 |
| Drake fine sandy loam, 2 to 10 percent slopes | 3,045 | .6 |
| Drake loamy fine sand, 2 to 10 percent slopes | 1,454 | .3 |
| Hassell loam, 2 to 5 percent slopes | 100 | [1] |
| Ima loam, 0 to 2 percent slopes | 610 | .1 |
| Ima loam, 2 to 5 percent slopes | 2,320 | .5 |
| Ima gravelly loam, light-colored variant, 2 to 5 percent slopes | 860 | .2 |
| Ima gravelly loam, light-colored variant, 5 to 10 percent slopes | 1,720 | .4 |
| La Lande loam, 0 to 2 percent slopes | 1,282 | .3 |
| La Lande loam, 2 to 5 percent slopes | 4,280 | .9 |
| Larimer gravelly loam | 1,286 | .3 |
| Lofton clay loam | 402 | .1 |
| Mansker loam, 0 to 2 percent slopes | 13,730 | 2.9 |
| Mansker loam, 2 to 5 percent slopes | 27,554 | 5.7 |
| Mansker loam, 5 to 10 percent slopes | 2,079 | .4 |
| Mansker fine sandy loam, 0 to 2 percent slopes | 2,165 | .5 |
| Mansker fine sandy loam, 2 to 5 percent slopes | 4,150 | .9 |
| Mansker fine sandy loam, 5 to 10 percent slopes | 620 | .1 |
| Manwood-Pullman loams | 5,677 | 1.2 |
| Montoya silty clay loam, 0 to 2 percent slopes | 4,343 | .9 |
| Montoya silty clay loam, 2 to 5 percent slopes | 2,117 | .4 |
| Newkirk sandy loam, 2 to 10 percent slopes | 844 | .2 |
| Portales fine sandy loam, 0 to 2 percent slopes | 500 | .1 |
| Portales loam, 0 to 2 percent slopes | 373 | .1 |
| Potter loam | 36,163 | 7.5 |
| Potter fine sandy loam | 1,513 | .3 |
| Pullman loam, 0 to 2 percent slopes | 186,480 | 38.9 |
| Pullman loam, 2 to 5 percent slopes | 3,747 | .8 |
| Pullman-Mansker loams, 0 to 2 percent slopes | 66,446 | 13.8 |
| Pullman-Mansker loams, 2 to 5 percent slopes | 6,016 | 1.3 |
| Regnier silt loam | 1,588 | .3 |
| Riverwash | 208 | [1] |
| Rough broken and stony land | 2,745 | .6 |
| San Jose fine sand, moderately deep over sand, 0 to 2 percent slopes | 490 | .1 |
| San Jose fine sand, moderately deep over sand, 2 to 5 percent slopes | 1,160 | .2 |
| Springer fine sandy loam, 0 to 2 percent slopes | 614 | .1 |
| Springer fine sandy loam, 2 to 5 percent slopes | 500 | .1 |
| Springer fine sandy loam, valleys, 0 to 5 percent slopes | 1,102 | .2 |
| Springer loamy fine sand, 0 to 5 percent slopes | 611 | .1 |
| Spur soils | 10,832 | 2.3 |
| Stony rough land, mixed materials | 2,490 | .5 |
| Stony rough land, Potter materials | 1,172 | .2 |
| Tivoli fine sand | 492 | .1 |
| Tucumcari loam, 0 to 2 percent slopes | 30 | [1] |
| Tucumcari loam, 2 to 5 percent slopes | 480 | .1 |
| Water and unclassified land | 4,138 | .9 |
| Total | 479,953 | 100.0 |

[1] Less than 0.1 percent.

the hue, value, and chroma, such as "10YR 5/4." These symbols, called Munsell color notations, are used by soil scientists to evaluate soil colors precisely.

For the profiles described in this report, color names and color symbols are given for both moist and dry soil. If only one color name, such as "dark brown," is given, this indicates the color of the soil varies but little when moist or dry. If two color names, such as "brown or dark brown," are given, the symbol for dry soil applies to the first term, "brown," and the symbol for moist soil applies to the second term, "dark brown."

The texture of the soil refers to the content of sand, silt, and clay. It is determined by the way the soil feels when rubbed between the fingers, and it is checked by laboratory analyses. Each mapping unit is identified by a textural name, such as "fine sandy loam." This refers to the texture of the surface layer, or A horizon.

Structure is indicated by the way the individual soil particles are arranged in larger grains, or aggregates, and the amount of pore space between the grains. The structure of a soil is determined by the strength or grade, the size, and the shape of the aggregates. For example, a horizon may have "weak, fine, blocky structure."

For definitions of other terms used in describing soils, refer to the glossary in the back part of the report.

## Alama Series

The Alama series consists of deep, reddish-brown soils that have a silty or loamy surface soil and a subsoil of blocky clay loam. The soils occur below the caprock on the gently sloping sides of valleys.

The surface soil, a reddish-brown loam or silt loam, is about 4 inches thick. The dark reddish-brown subsoil is about 24 inches thick. A zone of lime accumulation occurs at depths of about 26 to 30 inches. The parent material, which underlies the accumulation of lime, is lighter colored and in some places overlies a buried soil. It consists of loamy sediments that have washed from sandstone, shale, and other rocks that lie both above and below the caprock. The soils have formed principally under a cover of blue grama and buffalograss.

The Alama soils resemble the Tucumcari soils. They are underlain, in many places, by a buried soil, however, and they have a less well-developed subsoil and a weaker zone of lime accumulation.

Typical profile of Alama loam (center of the west section line of sec. 17, T. 8 N., R. 27 E.):

$A_1$ 0 to 4 inches, reddish-brown or dark reddish-brown (5YR 5/3, dry; 4/3, moist) loam; compound structure—weak, coarse, prismatic to moderate, coarse, granular; soft when dry, very friable when moist; noncalcareous; clear, smooth lower boundary.

$B_2$ 4 to 26 inches, dark reddish-brown (5YR 3/2, dry; 3/3, moist) clay loam; strong, medium, subangular blocky structure; very hard when dry, slightly sticky when wet; thin, patchy clay films occur principally on the vertical faces of the aggregates; strongly calcareous; clear, smooth lower boundary.

$C_{ca}$ 26 to 45 inches, reddish-brown or dark reddish-brown (5YR 4/3, dry; 3/3, moist), heavy loam; moderate, medium, subangular blocky structure; hard when dry, firm when moist; a few, thin, patchy clay films on some aggregates; strongly calcareous and has accumulations of lime in thin seams; clear, smooth lower boundary.

C 45 to 52 inches, light reddish-brown or reddish-brown (2.5YR 6/4, dry; 4/5, moist) loam; massive; hard when dry, firm when moist; contains some partly weathered fragments of loamstone; strongly calcareous.

The subsoil is slowly permeable. If the range is in poor condition, surface runoff is generally medium. These soils are used for range.

**Alama loam, 0 to 2 percent slopes** (Aa).—This soil occurs in the southwestern part of the survey area. All of it is in climatic zone 5. It is in capability unit VIc-1 and in the Plains Upland range site.

**Alama loam, 2 to 5 percent slopes** (Ab).—This soil is more likely to be eroded by water than Alama loam, 0 to 2 percent slopes. A few gullies have started to form in some areas. This soil is in climatic zone 5. It is in capability unit VIc-1 and in the Plains Upland range site.

**Alama silt loam, 0 to 2 percent slopes** (Ac).—This soil has a surface layer of silt loam; otherwise, its profile is like the one described for the Alama series. The areas are subject to occasional overflow. In the survey area, this soil is inextensive. It is only in the northwestern part. In the watershed of Alamogordo Creek to the west, however, it occurs in large areas.

This soil is used for pasture. If the range is in poor condition, surface runoff is rapid. This soil is in climatic zone 5. It is in capability unit VIc-1 and in the Plains Upland range site.

**Alama silt loam, 2 to 5 percent slopes** (Ad).—This soil has steeper slopes than Alama silt loam, 0 to 2 percent slopes, but is similar in other characteristics. It is in climatic zone 5. It is in capability unit VIc-1 and in the Plains Upland range site.

## Amarillo Series

The Amarillo soils are deep and are nearly level to gently sloping. They have a surface layer of loam or fine sandy loam and a subsoil of sandy clay loam.

The surface soil is reddish brown and is about 4 inches thick. It is underlain by a reddish-brown subsoil that is mainly blocky in structure.

These soils have formed under grass in moderately sandy calcareous material that, in places, has been reworked by wind. They have a finer textured subsoil and their profile is more strongly developed than that of the Springer soils. The Amarillo soils are lighter colored than the Pullman soils, have a less compact subsoil, and have formed in coarser textured material.

Typical profile of Amarillo loam:

$A_1$ 0 to 4 inches, reddish-brown or dark reddish-brown (5YR 5/4, dry; 3/3, moist) loam; weak, coarse, subangular blocky structure breaking to weak, fine, granular; noncalcareous; abrupt, smooth lower boundary.

$B_1$ 4 to 7 inches, reddish-brown or dark reddish-brown (5YR 5/3, dry; 3/3, moist) loam; weak, very coarse prismatic structure breaking to moderate, coarse, subangular blocky; extremely hard when dry, firm when moist; thin, patchy clay films, chiefly on the vertical faces of the aggregates; noncalcareous; clear, smooth lower boundary.

$B_{21}$ 7 to 16 inches, reddish-brown or dark reddish-brown (5YR 5/4, dry; 3/4, moist), heavy sandy clay loam; weak to moderate, coarse, prismatic structure breaking to moderate to strong, medium, angular and subangular blocky; very hard when dry, firm

when moist; continuous, moderate clay films on aggregates; noncalcareous; gradual, smooth lower boundary.

$B_{22}$ 16 to 24 inches, reddish-brown or dark reddish-brown (5YR 5/4, dry; 3/4, moist), heavy sandy clay loam; weak to moderate, coarse, prismatic structure breaking to moderate to strong, medium, subangular blocky; hard when dry, friable when moist; thin, continuous clay films on aggregates; noncalcareous; gradual, smooth lower boundary.

$B_{3ca1}$ 24 to 32 inches, reddish-brown or dark reddish-brown (5YR 5/5, dry; 3/5, moist) sandy clay loam; weak to moderate, coarse, subangular blocky structure; hard when dry, friable when moist; thin, nearly continuous clay films on aggregates; noncalcareous but contains a few small concretions of calcium carbonate; gradual, smooth lower boundary.

$B_{3ca2}$ 32 to 40 inches, reddish-brown or dark reddish-brown (5YR 5/5, dry; 3/5, moist) sandy clay loam; weak, coarse, subangular blocky structure; hard when dry, friable when moist; thin, patchy clay films, principally on the vertical faces of the aggregates; calcareous, with lime mainly in seams and in small concretions; gradual, smooth lower boundary.

$B_{2bca}$ 40 to 60 inches +, light reddish-brown or reddish-brown (5YR 6/4, dry; 4/4, moist) sandy clay loam; moderate, medium, subangular blocky structure; hard when dry, friable when moist; thin, nearly continuous clay films on surface of aggregates; strongly calcareous, with a prominent accumulation of lime.

Permeability of the subsoil is moderate.

**Amarillo loam, 0 to 2 percent slopes** (Ag).—This soil can be used for crops or pasture. For dryland farming, it is in capability unit IIIc-1 (climatic zone 3) and in capability unit IVc-1 (climatic zone 4). For irrigated farming, it is in capability unit IIe-1. This soil is in the Plains Upland range site.

**Amarillo loam, 2 to 5 percent slopes** (Ah).—This soil can be used for crops or pasture. For dryland farming, it is in capability unit IIIc-1 (climatic zone 3) and in capability unit IVc-1 (climatic zone 4). For irrigated farming, it is in capability unit IIIe-2. This soil is in the Plains Upland range site.

**Amarillo loam, valleys, 0 to 2 percent slopes** (Ak).—This soil occurs below the caprock in the extreme western part of the survey area. Its parent material is similar to that of the other Amarillo soils but was washed down onto the sides of the valleys. This soil occurs only in climatic zone 5. Because of the limited amount of rainfall, it is not suited to cultivated crops. This soil is in capability unit VIc-1 (climatic zone 5) and in the Plains Upland range site.

**Amarillo loam, valleys, 2 to 5 percent slopes** (Am).—Except for its stronger slopes, this soil is similar to Amarillo loam, valleys, 0 to 2 percent slopes. It is in capability unit VIc-1 (climatic zone 5) and in the Plains Upland range site.

**Amarillo fine sandy loam, 0 to 2 percent slopes** (Ae).—The profile of this soil is similar to that described for the Amarillo series, but the surface soil consists of fine sandy loam, and because of erosion it is from 2 to 10 inches thick. The fine sandy loam is single grain or has a coarse prismatic structure. In cultivated areas there is a serious risk of wind erosion. For dryland farming, this soil is in capability unit IIIe-1 (climatic zone 3) and in capability unit IVe-1 (climatic zone 4). For irrigation farming, it is in capability unit IIIe-3. This soil is in the Sandy Plains range site.

**Amarillo fine sandy loam, 2 to 5 percent slopes** (Af).—This soil occurs only in small areas and is not extensive. In cultivated areas there is a serious risk of erosion. For dryland farming, this soil is in capability unit IIIe-1 (climatic zone 3) and in capability unit IVe-1 (climatic zone 4). It is in the Sandy Plains range site.

## Arch Series

The Arch soils are shallow and light colored and are strongly calcareous. They have formed in highly calcareous material that has been deposited in the basins of shallow lakes in the upland.

The surface soil is grayish brown and is about 3 to 5 inches thick. It is strongly calcareous. Below this is the gray subsoil, which has a weak, blocky structure, is also strongly calcareous, and is about 8 inches thick. The underlying loamy materials are light gray and massive.

The parent materials of the Arch soils are lake sediments. The lake sediments appear to have been modified by the deposition of calcium carbonate through ground water. The soils have formed under a moderately dense cover of short grasses. They occur only along the larger drainageways and in playas. The slopes range from 0 to 5 percent.

The Arch soils are lighter colored and shallower than the Portales soils, and their profile is not so well developed. They are lighter colored than the Mansker soils.

Typical profile of Arch loam (center of the northern boundary of sec. 20, T. 5 N., R. 30 E.):

A+ 0 to 1 inch, grayish-brown or dark grayish-brown (10YR 5/2, dry; 3.5/2, moist) loam; weak, thin, platy structure breaking to weak, fine, granular; soft when dry, very friable when moist; strongly calcareous; abrupt, smooth lower boundary.

$A_1$ 1 to 3 inches, grayish-brown or very dark grayish-brown (10YR 5/2, dry; 3/2, moist), heavy loam; weak, fine, subangular blocky structure breaking to moderate, fine, granular; slightly hard when dry, very friable when moist; strongly calcareous; clear, smooth lower boundary.

$B_{ca}$ 3 to 11 inches, gray or dark-gray (10YR 5/1, dry; 4/1, moist), light clay loam; weak to moderate, coarse, prismatic structure breaking to weak to moderate, coarse, subangular blocky; very hard when dry, friable when moist; a few, thin, patchy clay films limited primarily to the vertical faces of the aggregates; strongly calcareous, with much finely divided lime; gradual, smooth lower boundary.

$C_{ca}$ 11 to 30 inches +, light-gray or grayish-brown (10YR 6/1, dry; 5/2, moist), light clay loam; massive (structureless) to weak, coarse, subangular blocky structure; hard when dry, friable when moist; strongly calcareous, with much calcium carbonate in very finely divided form and in a few small seams and concretions.

The subsoil is moderately permeable, and surface runoff ordinarily is not a problem. Natural fertility is moderate to low.

**Arch loam** (Ao).—This nearly level to very gently sloping soil is in capability unit VIs-1 (climatic zones 3 and 4) and in the Plains Upland range site.

**Arch fine sandy loam** (An).—Except for having a surface layer of fine sandy loam, the profile of this soil is like the profile described for the Arch series. The soil is nearly level to very gently sloping. It is in capability

unit VIe-1 (climatic zones 3 and 4) and in the Sandy Plains range site.

**Arch loamy fine sand** (Ap).—This soil has a profile similar to that described for the Arch series, but its surface layer is loamy fine sand. This soil is also slightly sandier throughout. The relief is nearly level to gently sloping. This soil is in capability unit VIe-1 (climatic zones 3 and 4) and in the Sandy Plains range site.

## Arvana Series

In the survey area the Arvana series consists of shallow, loamy soils that overlie hard caliche. Their surface soil is generally brown and has a weak, granular structure. It is about 4 inches thick. Below this is a reddish-brown, loamy subsoil that is about 10 inches thick and has a blocky structure. Hard caliche is at a depth of about 14 inches.

These soils have formed in Tertiary outwash of the Sandy Plains. This material has been reworked and blown onto the caliche caprock. The soils have formed under a cover of grama grasses, buffalograss, dropseed grasses, and other short grasses and bunch grasses. There are a few yucca plants and small shrubs.

The Arvana soils are darker and have a more strongly developed subsoil than the Potter soils. They are not so deep as the Amarillo soils.

Typical profile of Arvana loam, shallow (530 feet west of the northeastern corner of sec. 23, T. 7 N., R. 27 E.):

$A_1$ 0 to 3 inches, brown or dark-brown (7.5YR 5/3, dry; 3/3, moist) loam; weak to moderate, fine, granular structure; soft when dry, very friable when moist; noncalcareous; clear, smooth lower boundary.

$B_1$ 3 to 5 inches, reddish-brown or dark reddish-brown (5YR 4/3, dry; 3/3, moist), heavy loam; weak to moderate, medium, prismatic structure that breaks to medium or fine, subangular blocky; slightly hard when dry, very friable when moist; thin, nearly continuous clay films; noncalcareous; clear, smooth lower boundary.

$B_2$ 5 to 11 inches, reddish-brown or dark reddish-brown (5YR 4/3, dry; 3/3, moist), light clay loam; moderate to strong, fine, angular blocky structure; hard when dry, friable when moist; thin, continuous clay films; clear, smooth lower boundary.

$B_{3ca}$ 11 to 14 inches, reddish-brown (5YR 5/4, dry; 4/4, moist) light clay loam; weak, medium, prismatic structure breaking to weak to moderate, medium, subangular blocky; hard when dry, friable when moist; thin, patchy clay films; calcareous, with a few, small concretions of calcium carbonate; abrupt, smooth lower boundary.

$D_r$ 14 inches +, hard bed of caliche.

The depth to caliche ranges from 10 to 20 inches. The permeability of the subsoil is moderate; in most places the caliche is broken sufficiently to permit the free downward movement of water.

**Arvana loam, shallow, 0 to 2 percent slopes** (At).—This soil is too shallow for dryland farming, but it is good for range. Near the town of House, it is used for irrigation farming. The moisture-holding capacity is low, but with light and frequent applications of water, fair yields of irrigated crops are obtained. This soil is in capability unit VIs-1 (climatic zones 3 and 4). For irrigation farming, it is in capability unit IVs-1. Range management is discussed under the Plains Upland range site.

**Arvana loam, shallow, 2 to 5 percent slopes** (Au).—This soil is on slopes along drainageways. It occurs with the Potter soils. It is in capability unit VIs-1 (climatic zones 3 and 4) and in the Plains Upland range site.

**Arvana fine sandy loam, shallow, 0 to 2 percent slopes** (Ar).—Except that the texture of the surface layer is fine sandy loam, the profile of this soil is like that described for the Arvana series. This soil is too shallow for dryland farming, but it is good for range. It is in capability unit VIe-1 (climatic zones 3 and 4) and in the Sandy Plains range site.

**Arvana fine sandy loam, shallow, 2 to 5 percent slopes** (As).—The profile of this soil is like that described for the Arvana series, except that the texture of the surface layer is fine sandy loam. This soil is in capability unit VIe-1 (climatic zones 3 and 4) and in the Sandy Plains range site.

## Church Series

The Church series consists of light-colored clays. The soils are on terraces that surround large, enclosed depressions or lakebeds in the uplands.

The surface soil is very thin and consists of clay loam. It is underlain by a subsoil of light-colored, heavy clay that has a blocky structure. In the substratum are light-colored, strongly calcareous, clayey materials.

The Church soils have formed in heavy clays washed down from surrounding areas. Since the clays were deposited, they have been modified through poor aeration and the presence of strongly calcareous ground water. The soils have formed under grasses, which were principally tobosagrass and vine-mesquite.

The Church soils are lighter colored than the Portales soils. Their subsoil is also finer textured.

Only one member of the Church series, Church clay loam, is mapped in this survey area.

Typical profile of Church clay loam:

$A_1$ 0 to 3 inches, light-gray to light brownish-gray (10YR 6/1.5, dry) to dark-gray or dark grayish-brown (10YR 4/1.5, moist) clay loam; soft when dry, very friable when moist; weak to moderate, fine, crumb structure; calcareous; clear, smooth lower boundary.

$B_1$ 3 to 5 inches, gray (2.5Y 5.5/1.5, dry) to dark-gray or dark grayish-brown (2.5Y 4.5/1.5, moist) silty clay; very hard when dry, firm when moist; weak to moderate, medium, subangular blocky structure breaking to moderate, medium granular; strongly calcareous; clear, smooth lower boundary.

$B_{21}$ 5 to 13 inches, gray or grayish-brown (2.5Y 5/1.5, dry) to dark-gray or dark grayish-brown (2.5Y 4/1.5, moist) clay; extremely hard when dry, very firm when moist; moderate, medium, prismatic structure breaking to moderate to strong, medium, subangular blocky; strongly calcareous; contains thin, patchy clay films on both horizontal and vertical faces of the soil aggregates; gradual, smooth lower boundary.

$B_{22}$ 13 to 26 inches, grayish-brown (10YR 5/2, dry) to dark grayish-brown (10YR 4/2, moist) clay; extremely hard when dry, very firm when moist; moderate, medium, subangular blocky structure; strongly calcareous; has thin, patchy clay films, principally on the vertical faces of the soil aggregates; gradual, smooth lower boundary.

$B_{3ca}$ 26 to 38 inches, grayish-brown or brown (10YR 5/2.5, dry) to dark grayish-brown or brown (10YR 4/2.5, moist), light clay; extremely hard when dry, firm when moist; weak, medium, subangular blocky structure; strongly calcareous; horizon of weak lime accumulation with visible lime occurring principally in small seams; gradual, smooth lower boundary.

$C_{ca}$ 38 to 60 inches, light brownish-gray (10YR 6/2, dry) to dark grayish-brown or grayish-brown (10YR 4.5/2, moist), heavy clay loam; very hard when dry, firm when moist; massive; strongly calcareous.

The color of the dry surface soil ranges from light gray to dark grayish brown. The depth to the zone of calcium carbonate accumulation ranges from 18 to 36 inches. The subsoil is very slowly permeable.

**Church clay loam** (Ca).—In some places this soil is nearly level, but in others the slopes are as much as 5 percent. In a few small areas, the slopes are steeper. This soil is in capability unit VIw-1 (climatic zones 3 and 4). For irrigation farming, it is in capability unit IVs-2. Range management is discussed in the description of the Heavy Bottom-lands range site.

## Clovis Series

In the Clovis series are brown, loamy soils that have a moderately developed subsoil. This is underlain by a prominent horizon of lime accumulation (soft caliche).

The surface soil is brown and noncalcareous and has moderate, fine and medium, granular structure. It is generally about 6 to 8 inches thick. The subsoil, a reddish-brown light clay loam to sandy clay loam, has a weak, subangular blocky structure and is about 24 inches thick.

The parent material of the Clovis soils is limy plains outwash. In places this material has been reworked by wind. The soils have formed under grass, predominantly blue grama and hairy grama with some side-oats grama and buffalograss.

The Clovis soils are not so thick as the Amarillo soils and have a less well developed subsoil and a more prominent zone of lime. They have a more strongly developed subsoil and a deeper profile than the Mansker soils.

The soils of the Clovis series are not mapped separately in this survey. They occur in small areas in intricate association with the Amarillo soils and were mapped with those soils as soil complexes. A profile description of the Amarillo soils is given in the description of the Amarillo series.

Typical profile of Clovis loam:

$A_1$ 0 to 5 inches, brown to dark-brown (7.5YR 4.5/2, dry; 3/2, moist) loam; moderate, fine and medium granular structure; slightly hard when dry, friable when moist; noncalcareous; clear, smooth lower boundary.

$A_3$ 5 to 9 inches, brown to dark-brown (7.5YR 4.5/3, dry; 3/3, moist) loam; weak, coarse, prismatic structure that breaks to weak, coarse, subangular blocky; very hard when dry, firm when moist; thin, patchy clay films, principally on the vertical faces of the aggregates; noncalcareous; gradual, smooth lower boundary.

$B_{21}$ 9 to 18 inches, reddish-brown (5YR 4.5/3, dry; 3.5/3, moist), light clay loam; weak to moderate, coarse prismatic structure that breaks to weak, coarse, subangular blocky; very hard when dry, firm when moist; thin, nearly continuous clay films; noncalcareous; gradual, smooth lower boundary.

$B_{22}$ 18 to 24 inches, reddish-brown (5YR 5/4, dry; 4/4, moist), light clay loam; weak, medium, prismatic structure that breaks to weak to moderate, medium, subangular blocky; very hard when dry, firm when moist; thin, nearly continuous clay films; noncalcareous; gradual, smooth lower boundary.

$B_{3ca}$ 24 to 30 inches, light reddish-brown to reddish-brown (5YR 6/4, dry; 5/4, moist) sandy clay loam; weak, medium, prismatic structure that breaks to weak, medium, subangular blocky; very hard when dry, friable when moist; calcareous, with visible lime concretions throughout the horizon; gradual, smooth lower boundary.

$C_{ca}$ 30 to 60 inches +, pink (7.5YR 8/4, dry; 7/4, moist), light sandy clay loam; massive; very hard when dry, friable when moist; very strongly calcareous.

The depth to the prominent zone of lime accumulation ranges from 16 to 36 inches.

**Clovis-Amarillo loams, 0 to 2 percent slopes** (Cc).—The profiles of these soils are like those described for the Clovis and Amarillo series. For dryland farming, these soils are in capability unit IIIc-1 (climatic zone 3) and in capability unit IVc-1 (climatic zone 4). For irrigation farming, they are in capability unit IIs-1. Range management is discussed in the description of the Plains Upland range site.

**Clovis-Amarillo loams, 2 to 5 percent slopes** (Cd).—These very inextensive soils occur around playa lakes. For dryland farming, they are in capability unit IIIc-1 (climatic zone 3) and in capability unit IVc-1 (climatic zone 4). They are in the Plains Upland range site.

**Clovis-Amarillo loams, valleys, 0 to 2 percent slopes** (Ce).—The soils of this complex occur only in the extreme western part of the survey area. They occupy benchlike areas below the caprock but above the floor of the valley. The parent material has washed down onto the sides of the valley. In most places, the soils are calcareous to the surface. They differ from other Clovis-Amarillo soils in having less clay in the B horizon and in having a weakly cemented layer of gravel and cobbles between depths of 19 and 25 inches. This complex is in capability unit VIc-1 (climatic zone 5) and in the Plains Upland range site.

**Clovis-Amarillo loams, valleys, 2 to 5 percent slopes** (Cf).—The soils of this complex are on very gentle slopes. They are in capability unit VIc-1 (climatic zone 5) and in the Plains Upland range site.

**Clovis-Amarillo fine sandy loams, 0 to 5 percent slopes** (Cb).—This complex consists of soils that have a surface layer of fine sandy loam. A few areas have slopes of more than 5 percent. These soils are well suited to cultivation. For dryland farming, they are in capability unit IIIe-1 (climatic zone 3) and in capability unit IVe-1 (climatic zone 4). For irrigation farming, they are in capability unit IIIe-4. This complex is in the Sandy Plains range site.

## Drake Series

The soils of the Drake series are light-colored, weakly developed fine sandy loams and loamy fine sands. They lie on the eastern and northeastern sides of the large playas or depressions in the uplands. They are on rolling hills, mostly above the level of the surrounding land.

The Drake soils have a very thin, light-colored surface soil with very weakly developed structure. The subsoil of brown fine sandy loam has weakly developed structure. Underlying this is light-colored, calcareous fine sandy loam. The profile is calcareous throughout.

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These soils are developing in calcareous sandy material that has been blown out of depressions or playas and deposited in hills and dunes. Because of the pattern in which these landforms have been established, the individual areas are not large. The soils have formed under grass, mainly grama grasses.

The Drake soils are lighter colored and coarser textured than the Church soils, and their subsoil is not so well developed.

Typical profile of Drake fine sandy loam (center of sec. 21, T. 5 N., R. 30 E.):

$A_1$ 0 to 1 inch, pale-brown or dark grayish-brown (10YR 6/3, dry; 4/2, moist) fine sandy loam; single grain to massive; loose; strongly calcareous; abrupt, smooth lower boundary.

AC 1 to 14 inches, brown or dark-brown (10YR 5/3, dry; 3/3, moist) fine sandy loam; weak, coarse, prismatic structure; loose; strongly calcareous; gradual, smooth lower boundary.

$C_1$ 14 to 30 inches, light-gray or light brownish-gray (10YR 7/2, dry; 6/2, moist) fine sandy loam; single grain to massive; loose; strongly calcareous, with spots of lime; clear, smooth lower boundary.

$C_2$ 30 inches +, very pale brown or pale brown (10YR 7/3, dry; 6/3, moist) fine sandy loam; single grain; loose; strongly calcareous.

These soils have a very severe hazard of erosion unless adequately protected with a good cover of grass.

**Drake fine sandy loam, 2 to 10 percent slopes** (Da).—The subsoil of this soil is moderately permeable. The profile is like that described for the Drake series. Included, however, is a small acreage in which the texture of the surface layer is loam.

This soil is in capability unit VIe-1 (climatic zones 3 and 4) and in the Sandy Plains range site.

**Drake loamy fine sand, 2 to 10 percent slopes** (Db).—The profile of this soil is similar to that described for the Drake series, but the surface soil is loamy fine sand. In addition, this soil is slightly sandier throughout the profile. The permeability of the subsoil is moderately rapid. This soil is in capability unit VIIe-1 (climatic zones 3 and 4) and in the Deep Sands range site.

## Hassell Series

The Hassell soils have a thin surface layer of brown loam and a subsoil of subangular blocky clay that is about 14 inches thick. Redbed shale is at a depth of about 30 inches. These soils occur below the caprock in the western part of the survey area. They lie mostly on the moderately sloping sides or floors of the valleys. Here, the redbed shale was exposed as the valleys were formed through erosion.

The parent material has weathered from redbed shale. Some of it may have been moved a short distance as slope wash. The soils have formed under a moderately thick cover of grasses, mainly alkali sacaton, tobosagrass, blue grama, and vine-mesquite.

The Hassell soils have a more strongly developed subsoil than the Montoya soils. They have developed largely from shale weathered in place. The Montoya soils, in contrast, have formed in material washed from the shale and deposited in stream valleys. The Hassell soils are deeper than the Regnier soils and have a more strongly developed subsoil.

Only one member of the Hassell series—Hassell loam, 2 to 5 percent slopes—was mapped in this survey area.

Typical profile of Hassell loam, 2 to 5 percent slopes (900 feet west and 100 feet south of the NW. corner, NE¼ sec. 20, T. 5 N., R. 27 E.):

$A_1$ 0 to 4 inches, brown or dark-brown (7.5YR 5/3, dry; 4/3, moist) loam; weak to moderate, fine, granular structure; slightly hard when dry, very friable when moist; calcareous; clear, smooth lower boundary.

$B_1$ 4 to 7 inches, brown or dark-brown (7.5YR 5/3, dry; 3.5/3, moist) sandy clay loam; weak, medium, subangular blocky structure that breaks to weak, fine, granular; hard when dry, friable when moist; calcareous; clear, smooth lower boundary.

$B_2$ 7 to 13 inches, reddish-gray to dark reddish-gray (5YR 5/2, dry; 4/2, moist) clay; moderate, medium, prismatic structure that breaks to moderate to strong, fine, angular blocky; very hard when dry, firm when moist; thin, nearly continuous clay films; strongly calcareous; gradual, smooth lower boundary.

$B_{3ca}$ 13 to 18 inches, reddish-gray to dark reddish-gray (5YR 5.5/2, dry; 4.5/2, moist) clay; weak, medium, prismatic structure that breaks to moderate to strong, fine, angular blocky; extremely hard when dry, very firm when moist; thin, patchy clay films, principally on the horizontal faces of the aggregates; strongly calcareous, with visible lime mostly in the form of soft concretions ½ to ¼ inch in diameter; gradual, wavy lower boundary.

C 18 to 31 inches, reddish-gray to dark reddish-gray (5YR 5/2, dry; 4/2, moist) clay; weak, medium, blocky structure; extremely hard when dry, very firm when moist; strongly calcareous, with some accumulation of calcium carbonate though much less than in horizon above; gradual, smooth lower boundary.

D 31 inches +, reddish-gray to dark reddish-gray (5YR 5.5/2, dry; 4.5/2, moist) redbed shale that is partly weathered in the uppermost few inches.

The subsoil is very slowly permeable.

**Hassell loam, 2 to 5 percent slopes** (Ha).—This is the only soil of the Hassell series mapped in this survey. It is very susceptible to water erosion unless protected with a good cover of grass. It is in capability unit VIe–2 (climatic zone 5) and in the Heavy Slopes range site.

## Ima Series

The Ima soils are deep, poorly developed, and loamy. They occur below the caprock and have formed in recent valley fill.

The brown, loamy surface soil is about 10 inches thick and has a weak, granular to blocky structure. There is a weak zone of lime accumulation below the surface layer, and then the parent material. Little or no subsoil has developed.

The loamy material contains waterworn gravel and was derived principally from the Ogallala formation. This material washed down from the escarpment and into the valley. The soils have formed under vegetation consisting primarily of blue grama and black grama.

The Ima soils contain less silt and more gravel and are not so red as the Regnier soils The Regnier soils have developed in redbed material.

Profile of Ima loam (center of the northern side of sec. 14, T. 5 N., R. 27 E.):

$A_1$ 0 to 3 inches, brown (7.5YR 4/2, dry) or dark-brown (7.5YR 3/2, moist), light loam; slightly hard when dry, very friable when moist; weak, thin, platy structure that breaks to moderate, fine, granular; calcareous; contains some waterworn gravel and cobbles but not enough for the soil to be classified as gravelly; clear, smooth lower boundary.

AC 3 to 7 inches, dark reddish-gray (5YR 4/2, dry) or dark reddish-brown (5YR 3/3, moist), light loam; slightly hard or hard when dry, very friable when moist; very weak, coarse, subangular blocky structure; strongly calcareous; gradual, smooth lower boundary.

$C_{ca}$ 7 to 17 inches, light reddish-brown (5YR 6/3, dry) or reddish-brown (5YR 4/3, moist), light sandy clay loam; hard when dry, friable when moist; massive (structureless); strongly calcareous, with a slight accumulation of lime that is visible principally in the form of soft concretions; gradual, smooth lower boundary.

C 17 to 60 inches, reddish-brown (5YR 5/3, dry; 5YR 4/3, moist) sandy loam; slightly hard to hard when dry, very friable when moist; massive (structureless).

There is some waterworn gravel scattered throughout the profile.

Profile of Ima gravelly loam, light-colored variant (600 feet west and 300 feet south of the northeastern corner of sec. 7, T. 5 N., R. 27 E.):

$A_{11}$ 0 to 5 inches, brown or dark-brown (7.5YR 5.5/3, dry; 4/3, moist) gravelly loam; weak to moderate, fine, granular structure; slightly hard when dry, friable when moist; about 25 to 30 percent of this horizon consists of waterworn gravel and cobbles; strongly calcareous; gradual, smooth lower boundary.

$A_{12}$ 5 to 9 inches, brown or dark-brown (7.5YR 5.5/3, dry; 4/3, moist) loam; weak, coarse, subangular blocky structure; hard when dry, very friable when moist; about 20 percent of this horizon consists of gravel; strongly calcareous; gradual, smooth lower boundary.

BC 9 to 14 inches, brown or dark-brown (7.5YR 5.5/3, dry; 4/3, moist), light sandy clay loam; weak, coarse, subangular blocky structure; hard when dry, very friable when moist; 10 to 20 percent of this horizon consists of waterworn gravel; strongly calcareous; lime visible in the form of a few, very small concretions of calcium carbonate; gradual, smooth lower boundary.

$C_{ca}$ 14 to 24 inches, brown or dark-brown (7.5YR 5.5/2, dry; 4/2, moist), light sandy clay loam; weak, coarse, subangular blocky structure; hard when dry, very friable when moist; 10 to 20 percent of this horizon consists of waterworn gravel; strongly calcareous; visible lime, principally in the form of soft concretions ⅛ to ¼ inch in diameter; gradual, smooth lower boundary.

C 24 to 34 inches, light-brown or brown (7.5YR 6/3, dry; 5/3, moist), light sandy clay loam; massive; hard when dry, very friable when moist; 10 to 20 percent of this horizon consists of waterworn gravel; strongly calcareous; some accumulation of calcium carbonate.

**Ima loam, 0 to 2 percent slopes** (Ic).—Except for having more gravel throughout the profile, this soil is similar to that described for the Ima series. This soil is in capability VIc-1 (climatic zone 5) and in the Plains Upland range site.

**Ima loam, 2 to 5 percent slopes** (Id).—The profile of this soil is like that described for the Ima series, but it has less gravel throughout. This soil is in capability unit VIc-1 (climatic zone 5) and in the Plains Upland range site.

**Ima gravelly loam, light-colored variant, 2 to 5 percent slopes** (Ia).—This soil occurs only below the caprock in the western part of the survey area. Because of the gravelly surface soil and moderately permeable subsoil, there is little surface runoff. This soil is in capability unit VIc-1 (climatic zone 5) and in the Plains Upland range site.

**Ima gravelly loam, light-colored variant, 5 to 10 percent slopes** (Ib).—This soil is too steep to be cultivated. There is little surface runoff, however, because the surface soil is gravelly and the subsoil is moderately permeable. This soil is in capability unit VIc-1 (climatic zone 5) and in the Plains Upland range site.

## La Lande Series

In the La Lande series are brownish, calcareous, deep, loamy soils. These soils are on the very gently sloping to moderately sloping sides of the broad, erosional valleys in the western part of the survey area.

The thin, reddish-gray, loamy surface soil is about 4 inches thick. It grades to reddish-brown, loamy subsoil that has subangular blocky structure. The underlying material is also loamy.

The La Lande soils have developed in material washed down from the caprock escarpment. This material has weathered mainly from sandstone, loamstone, and clay shale of the redbeds. The vegetation is principally blue grama.

These soils are not so gravelly as the Ima soils, but they have a more strongly developed subsoil.

Typical profile of La Lande loam:

$A_1$ 0 to 4 inches, reddish-gray or dark reddish-brown (5YR 5/2.5, dry; 3/2.5, moist) loam; weak, medium, subangular blocky structure that breaks to weak, fine, granular; faintly platy in the uppermost inch; slightly hard when dry, very friable when moist; slightly calcareous; clear, smooth lower boundary.

AB 4 to 7 inches, reddish-brown or dark reddish-brown (5YR 4.5/3, dry; 3/3, moist) loam; weak, coarse, prismatic structure that breaks to weak to moderate, medium, subangular blocky; hard when dry, friable when moist; a few, thin, patchy clay films on aggregates; slightly calcareous; clear, smooth lower boundary.

$B_2$ 7 to 11 inches, reddish-brown (5YR 5/3, dry; 4/3, moist), heavy loam; weak to moderate, coarse, prismatic structure that breaks to moderate, coarse, subangular blocky; hard when dry, friable when moist; thin, patchy clay films on aggregates; calcareous; gradual, smooth lower boundary.

$B_3$ 11 to 20 inches, reddish-brown (5YR 5/3, dry; 4/3, moist) loam; weak to moderate, coarse, prismatic structure that breaks to moderate, coarse, subangular blocky; slightly hard when dry, friable when moist; a few, thin, patchy clay films, principally on vertical faces of aggregates; strongly calcareous; gradual, smooth lower boundary.

$C_{ca}$ 20 to 33 inches, light reddish-brown or reddish-brown (5YR 6/4, dry; 4/4, moist) loam; very weak, coarse, subangular blocky structure; slightly hard when dry, friable when moist; strongly calcareous; lime occurs principally as soft concretions ⅛ to ½ inch in diameter; clear, smooth lower boundary.

$B_{2bca}$ 33 to 48 inches, light reddish-brown or reddish-brown (5YR 6.5/3.5, dry; 4.5/3.5, moist) silty clay loam; moderate, medium, prismatic structure that breaks to moderate, medium, subangular blocky; hard when dry, firm when moist; thin, continuous clay films; calcareous; contains soft concretions of lime; gradual, smooth lower boundary.

C 48 to 60 inches, reddish-brown (5YR 5/3.5, dry; 4/3, moist) loam; massive; slightly hard when dry, friable when moist; strongly calcareous, with some lime accumulations.

The permeability of the subsoil is moderate.

**La Lande loam, 0 to 2 percent slopes** (La).—Because of the low amount of rainfall, this soil is not suitable for dryland farming. It is in capability unit VIc-1 (climatic zone 5) and in the Plains Upland range site.

**La Lande loam, 2 to 5 percent slopes** (Lb).—This soil is not suitable for dryland farming. It is in capability unit VIc-1 (climatic zone 5) and in the Plains Upland range site.

## Larimer Series

In the Larimer series are weakly developed gravelly loams that have a thin subsoil. These soils lie on rolling slopes.

The very thin, brown surface soil is about 4 inches thick. The slightly lighter colored subsoil of gravelly loam has a weak, blocky structure and is also about 4 inches thick. Very limy gravelly loam is at a depth of about 12 inches.

The Larimer soils have formed from a mixture of gravelly outwash that was probably reworked by ancient streams. The native vegetation consists principally of side-oats grama, blue grama, and needlegrass, but there is some black grama on the southern slopes.

The Larimer soils are more gravelly and are shallower than the Ima and La Lande soils.

Only one member of the Larimer series, Larimer gravelly loam, is mapped in this survey area.

Typical profile of Larimer gravelly loam (at the center of the NE¼ sec. 31, T. 8 N., R. 28 E.):

$A_1$ 0 to 4 inches, brown to very dark brown (7.5YR 4.5/2, dry; 2/2, moist) gravelly loam; weak to moderate, fine, crumb structure; slightly hard when dry, very friable when moist; slightly calcareous; gradual, smooth lower boundary.

$B_2$ 4 to 8 inches, dark grayish-brown to very dark brown (10YR 4/2, dry; 2/2, moist) gravelly loam; weak to moderate, medium, subangular blocky structure that breaks to weak, medium, granular; slightly hard when dry, very friable when moist; thin, patchy clay films on faces of aggregates; calcareous; gradual, smooth lower boundary.

$C_{ca}$ 8 to 11 inches, gray to dark-gray (10YR 5/1.5, dry; 10YR 4/1.5, moist) very gravelly loam; single grain (structureless); slightly hard when dry, friable when moist; 60 to 80 percent of this horizon consists of waterworn gravel; strongly calcareous; lime occurs principally in finely divided form; gradual, smooth lower boundary.

$D_{ca}$ 11 to 20 inches +, white to light-gray (10YR 8/2, dry; 7/2, moist) extremely gravelly loam; single grain (structureless); slightly hard when dry, friable when moist; about 80 percent of this horizon consists of waterworn gravel; strongly calcareous, with a prominent accumulation of lime in finely divided form.

Penetration of grass roots is slowed in many places by lime-cemented gravel that occurs between depths of 20 and 30 inches. There is little runoff, and the permeability of the subsoil is moderately rapid. The available moisture-holding capacity is low.

**Larimer gravelly loam** (Lc).—Most of this soil is on rolling slopes of 5 to 20 percent, but a small part of it is gently sloping. The soil is in capability unit VIs–2 (climatic zones 3 and 4) and in the Shallow Upland range site.

## Lofton Series

These are deep, dark-colored soils that have a thin surface layer and a silty clay loam subsoil. They lie along drainageways and in the large depressions of the uplands.

The reddish-brown surface soil has a weak, platy structure. The subsoil is about 18 inches thick and is reddish brown; it has a subangular blocky structure. Below this is calcareous silty material.

The Lofton soils have formed in material that has been washed into drainageways or lake basins. This material has been modified by strongly calcareous ground water. The natural vegetation consists primarily of grasses, mainly western wheatgrass, switchgrass, and buffalograss, and of some blueweed.

These soils are more clayey than the associated Portales soils. They are darker colored and less clayey than the Church soils.

Only one member of the Lofton series, Lofton clay loam, is mapped in the survey area.

Typical profile of Lofton clay loam (900 feet east and 300 feet south of the northeastern corner of sec. 29, T. 5 N., R. 30 E.):

$A_1$ 0 to 4 inches, reddish-brown or dark reddish-brown (5YR 4/4, dry; 3/4, moist) clay loam; weak, platy structure; friable; noncalcareous; abrupt, smooth lower boundary.

$B_2$ 4 to 16 inches, dark reddish-brown (5YR 3/2, dry; 2/2, moist) silty clay loam; moderate, medium, subangular blocky structure; slightly hard when dry, soft when moist; noncalcareous; clear, smooth lower boundary.

$B_{2ca}$ 16 to 24 inches, reddish-brown or dark reddish-brown (5YR 4/3, dry; 3/4, moist), heavy silt loam; moderate, fine, subangular blocky structure; soft; strongly calcareous; clear, wavy lower boundary.

$C_{ca1}$ 24 to 28 inches, pink or light-brown (7.5YR 8/4, dry; 6/4, moist) silt loam; massive (structureless) to weak, subangular blocky structure; firm when dry, soft when moist; strongly calcareous; abrupt, smooth lower boundary.

$C_{ca2}$ 28 inches +, pink or light-brown (7.5YR 8/4, dry; 6/4, moist) fine sandy loam; weak, coarse, prismatic structure to single grain (structureless); loose when dry, soft when moist; strongly calcareous.

Lofton soils are fairly uniform in profile characteristics. The permeability of the subsoil is slow. These soils receive runoff water from adjoining areas, and occasionally water stands on the surface for a few days.

**Lofton clay loam** (Ld).—This soil is level to nearly level. It occurs only in climatic zone 4 and is in capability unit VIw-2 and in the Plains Bottom-lands range site.

## Mansker Series

In the Mansker series are shallow to moderately deep, strongly calcareous soils that show little profile development. They have formed around intermittent lakes or on slopes adjacent to stream channels in the upland.

The brown, loamy surface soil is only about 3 inches thick and is underlain by brown clay loam that has weak, prismatic structure. A layer of soft caliche occurs between depths of 15 and 26 inches (fig. 2).


*Figure 2.*—**Profile of Mansker loam showing light-colored caliche below a depth of 1 foot.**

The parent material consists of very limy plains outwash. The loamy soils of this series have a cover of short grasses, mainly blue grama and buffalograss. On the fine sandy loams, the more common grasses are sideoats grama, needle-and-thread, blue grama, and black grama.

These soils are deeper than the Potter soils. They are shallower than the Pullman soils, and their subsoil is not so well developed.

Typical profile of Mansker loam (50 feet east of the road in the SW¼NW¼NW¼ sec. 34, T. 8 N., R. 33 E.):

$A_1$ 0 to 3 inches, brown or dark-brown (7.5YR 5/3, dry; 3/2, moist) loam; weak, fine, subangular blocky structure that breaks to moderate, fine, granular; the upper one-fourth inch of this horizon has a weak, platy structure; soft when dry, very friable when moist; strongly calcareous; gradual, smooth lower boundary.

AC 3 to 9 inches, brown or dark-brown (7.5YR 4.5/2, dry; 3/2, moist), light clay loam; weak, coarse, prismatic structure that breaks to moderate, coarse, subangular blocky; hard when dry, friable when moist; strongly calcareous; gradual, wavy lower boundary.

$C_{ca1}$ 9 to 15 inches, light-brown or brown (7.5YR 6/3, dry; 5/3, moist), light clay loam; weak, coarse, subangular blocky structure; hard when dry, friable when moist; strongly calcareous; lime visible, mostly as soft concretions ⅛ to ¼ inch in diameter; gradual, wavy lower boundary.

$C_{ca2}$ 15 to 26 inches +, pink (7.5YR 8/4, dry; 7/4, moist), light clay loam; massive; hard when dry, very friable when moist; strongly calcareous, with large amounts of finely divided lime.

Little water runs off the Mansker soils. The permeability of the subsoil is moderately rapid. Because they contain a large amount of lime, the soils are very susceptible to wind erosion.

**Mansker loam, 0 to 2 percent slopes** (Md).—For dryland farming, this soil is in capability unit IVe-3 (climatic zones 3 and 4). For irrigation farming, it is in capability unit IVs-3. This soil is in the Plains Upland range site.

**Mansker loam, 2 to 5 percent slopes** (Me).—Because of the degree of slope and the severe hazard of wind and water erosion, this soil is not cultivated. It is in capability unit VIe-3 (climatic zones 3 and 4) and in the Plains Upland range site.

**Mansker loam, 5 to 10 percent slopes** (Mf).—This soil is too strongly sloping to be cultivated; it is suitable only for permanent vegetation. It is in capability unit VIe-3 (climatic zones 3 and 4) and in the Plains Upland range site.

**Mansker fine sandy loam, 0 to 2 percent slopes** (Ma).—Except for having a surface layer of fine sandy loam about 6 inches thick, the profile of this soil is like that described for the Mansker series. Under cultivation, this soil is very susceptible to wind erosion. For dryland farming, it is in capability unit IVe-3 (climatic zone 3), and for irrigation farming, it is in capability unit IVs-3. The areas in climatic zone 4 are not suitable for cultivation and are in capability unit VIe-1. This soil is in the Sandy Plains range site.

**Mansker fine sandy loam, 2 to 5 percent slopes** (Mb).—Because of the degree of slope and the severe hazard of wind and water erosion, this soil is not suitable for dryland farming. For irrigation farming, it is in capability unit IVe-4. Nonirrigated areas are in capability unit VIe-1 (climatic zones 3 and 4). Range management is discussed under the Sandy Plains range site.

**Mansker fine sandy loam, 5 to 10 percent slopes** (Mc).—This soil is suitable only for permanent vegetation. It is in capability unit VIe-1 (climatic zones 3 and 4) and in the Sandy Plains range site.

## Manwood Series

In the Manwood series are soils that have a brown, loamy surface layer and a subsoil of dark-brown clay. The subsoil is predominantly blocky, but the upper part is columnar (fig. 3). A layer of hard caliche is at depths of 16 to 24 inches.

The parent material consists mainly of calcareous, clayey plains outwash, but in places some sandier material has been blown onto the surface. These soils lie in small depressions within areas of Pullman soils. They have formed under a thin stand of short grasses.

The Manwood soils are not so deep, have a more clayey subsoil, and contain more salts than the Pullman soils.

The Manwood soils of this survey area are mapped only in a complex with the Pullman soils. Most of this complex is made up of Pullman soils; the Manwood soils, which occur in scattered solodized-Solonetz, or scab, spots within areas of Pullman soils, comprise only about 5 percent of the acreage. A profile typical of the Pullman soils is described in the discussion of the Pullman series.

Typical profile of Manwood loam (SW¼SE¼ sec. 23, T. 8 N., R. 27 E.):

$A_1$ 0 to 3 inches, brown or dark-brown (7.5YR 5.5/2, dry; 4/2, moist) loam; moderately fine, medium, platy structure; soft when dry, very friable when moist; noncalcareous; clear, smooth lower boundary.

***Figure 3.*—Profile of a Manwood soil showing columnar structure in the upper part of the subsoil.**

$A_2$ 3 to 4 inches, pinkish-gray or brown (7.5YR 7/3, dry; 5/2, moist) loam; moderate, thin, platy structure; soft when dry, very friable when moist; noncalcareous; abrupt, smooth lower boundary.

$B_{21}$ 4 to 7 inches, very dark brown (7.5YR 2/2, moist) clay; weak, medium, columnar structure that breaks to strong, fine and medium, angular blocky; extremely hard when dry, very firm when moist; strong, continuous clay films on aggregates; noncalcareous; gradual, smooth lower boundary.

$B_{22}$ 7 to 13 inches, dark-brown (7.5YR 3/3, moist) clay; weak, coarse, prismatic structure that breaks to moderate, medium, angular blocky; extremely hard when dry, very firm when moist; strong, continuous clay films on aggregates; slightly calcareous; gradual, smooth lower boundary.

$B_{3ca}$ 13 to 18 inches, dark-brown (7.5YR 3/3, moist) clay; weak to moderate, coarse and medium, subangular blocky structure; very hard when dry, firm when moist; moderate, continuous clay films on aggregates; strongly calcareous, and many nodules of calcium carbonate, disseminated lime, and other salts; abrupt, smooth lower boundary.

$D_r$ 18 inches +, hard, indurated caliche.

Runoff is rapid from the scab spots, and water often stands in small depressions for several days. The permeability of the subsoil is very slow. Once the surface soil has been eroded, revegetation is very slow. These soils contain more exchangeable sodium than any other soils in the survey area.

**Manwood-Pullman loams** (Mg).—The soils of this inextensive complex are nearly level and occur only in the northwestern part of the survey area. They are in capability unit VIs-1 (climatic zone 4) and in the Plains Upland range site.

## Montoya Series

The Montoya series consists of deep, reddish-brown, weakly developed, calcareous, clayey soils that lie on the flood plains below the caprock. They have a thin surface layer of silty clay loam underlain by clayey material of blocky structure.

The parent material consists of alluvium washed in from the redbeds that lie below the caprock. It has a silty clay texture and a reddish-brown color. These soils have formed under vegetation consisting mainly of tobosagrass, alkali sacaton, and galleta grasses.

The Montoya soils are more clayey than the La Lande soils, which have a well-developed profile. They are redder and more clayey than the Ima soils and lack the waterworn gravel typical of those soils.

Typical profile of Montoya silty clay loam:

A+ 0 to 2½ inches, reddish-brown (2.5YR 5.5/4, dry; 4.5/4, moist) silty clay loam; moderate, very thick, platy structure that breaks to moderate, thin, platy; hard when dry, friable when moist; strongly calcareous; clear, smooth lower boundary.

$A_1$ 2½ to 8 inches, reddish-brown or dark reddish-brown (2.5YR 4.5/4, dry; 3.5/4, moist) silty clay loam; moderate, fine, angular blocky structure; extremely hard when dry, friable when moist; strongly calcareous; gradual, smooth lower boundary.

AC 8 to 21 inches, reddish-brown or dark reddish-brown (2.5YR 4/4, dry; 3/4, moist) silty clay; moderate, medium and fine, angular blocky structure; extremely hard when dry, firm when moist; strongly calcareous; clear, smooth lower boundary.

$C_1$ 21 to 28 inches, reddish-brown or red (2.5YR 5/5, dry; 4/5, moist) silty clay; weak, fine, angular blocky structure; extremely hard when dry, friable when moist; strongly calcareous; some accumulations of calcium carbonate, mostly in the form of thin seams; clear, smooth lower boundary.

$C_2$ 28 to 44 inches, reddish-brown or red (2.5YR 5/5, dry; 4/5, moist) silty clay; weak, medium, subangular blocky structure; very hard when dry, friable when moist; strongly calcareous, and some accumulations of calcium carbonate, chiefly in the form of thin, fine seams; gradual, smooth lower boundary.

$C_3$ 44 to 54 inches +, reddish-brown (2.5YR 5.5/5, moist) silty clay; massive (structureless) to very weak, coarse, subangular blocky structure; extremely hard when dry, firm when moist; strongly calcareous.

Runoff is rapid on these soils, which receive runoff water from the nearby slopes. The permeability of the subsoil is very slow.

**Montoya silty clay loam, 0 to 2 percent slopes** (Mh).—This soil lies in climatic zone 5 and is in capability unit VIw-1. It is in the Heavy Bottom-lands range site.

**Montoya silty clay loam, 2 to 5 percent slopes** (Mk).—This soil is best suited to grasses; some areas have good stands of galleta and sacaton grasses. This soil is in capability unit VIe-2 (climatic zone 5) and in the Heavy Slopes range site.

## Newkirk Series

In the Newkirk series are shallow, brown, loamy soils that occur below the caprock in the western part of the survey area.

The surface soil is loamy and is about 6 inches thick. Beneath this is a subsoil of sandy clay loam that has a weak, subangular blocky structure and is underlain by a weak zone of lime.

These soils are developing in loamy material that has weathered from soft sandstone and sandy shale. The parent rocks occur below the caprock. Blue grama and black grama are the main plants, but there is some juniper and yucca.

These soils have a strongly developed subsoil similar to that of the La Lande soils, but they are shallower than the La Lande soils.

Only one member of the Newkirk series, Newkirk sandy loam, 2 to 10 percent slopes, is mapped in the survey area.

Typical profile of Newkirk sandy loam (one-fourth mile north of the southeastern corner of sec. 7, T. 8 N., R. 27 E.):

$A_1$ 0 to 3 inches, brown or dark-brown (7.5YR 5/3, dry; 3/3, moist) sandy loam; weak, fine, granular structure; soft when dry, very friable when moist; noncalcareous; clear, smooth lower boundary.

AB 3 to 6 inches, brown or dark-brown (7.5YR 4/3, dry; 3/3, moist) sandy loam; weak to moderate, coarse, subangular blocky structure; slightly hard when dry, very friable when moist; thin, patchy clay films, principally on the vertical faces of the aggregates; noncalcareous; clear, smooth lower boundary.

$B_{21}$ 6 to 12 inches, brown or dark reddish-brown (7.5YR 4/3, dry; 5YR 3/3, moist) sandy clay loam; weak, very coarse, prismatic structure that breaks to weak, coarse, subangular blocky; slightly hard when dry, very friable when moist; thin, continuous clay films; noncalcareous; gradual, smooth lower boundary.

$B_{22}$ 12 to 17 inches, brown or dark reddish-brown (7.5YR 4.5/3, dry; 5YR 3.5/3, moist) sandy clay loam; weak to moderate, coarse, prismatic structure that breaks to weak, coarse, subangular blocky; hard when dry, friable when moist; thin, continuous clay films; noncalcareous; clear, wavy lower boundary.

$B_{3ca}$ 17 to 19 inches, brown (7.5YR 5/3, dry; 4/3, moist) sandy clay loam; weak, coarse, subangular blocky; hard when dry, friable when moist; calcareous, with some lime visible in the form of thin, myceliated seams; gradual, smooth lower boundary.

D 19 inches +, brown to reddish-brown (7.5YR 5/3, dry; 5YR 4/3, moist), partly weathered bedrock of soft sandstone and sandy shale.

The thickness of the various horizons differs slightly. In contrast to the profile just described for the series, the depth to bedrock generally ranges from 10 to 20 inches. In a few places bedrock occurs at a greater depth. Runoff is very slow, and the permeability of the subsoil is moderate.

**Newkirk sandy loam, 2 to 10 percent slopes** (Na).—This soil is not suited to cultivation. It is in capability unit VIe-1 (climatic zone 5) and in the Sandy Plains range site.

## Portales Series

The Portales soils are moderately deep, loamy soils of the High Plains. The surface soil is loamy and is about 6 inches thick. It is underlain by a subsoil of very dark brown loam that has a blocky structure. Lacustrine material that is high in lime occurs at depths of 20 to 30 inches.

These soils have developed in calcareous plains outwash that has filled old drainageways and lake basins. Old lakebed material underlies these soils. The original vegetation consisted of short grasses, mainly buffalograss and blue grama.

The Portales soils are darker colored, less limy, and deeper than the Arch soils. They are sandier and more permeable than the Lofton soils.

Typical profile of Portales fine sandy loam:

A+ 0 to 1 inch, reddish-brown or dark reddish-brown (5YR 5/3, dry; 3/3, moist) fine sandy loam; weak, platy structure; soft and loose when dry; noncalcareous; abrupt, smooth lower boundary.

$A_1$ 1 to 6 inches, dark-brown (7.5YR 4/2, dry; 3/2, moist) fine sandy loam; massive to single grain (structureless); loose when dry or moist; noncalcareous; abrupt, smooth lower boundary.

$B_2$ 6 to 14 inches, dark-brown (7.5YR 4/2, dry; 3/2, moist) loam; moderate, medium, prismatic structure that breaks to moderate, medium, subangular blocky; hard when dry, friable when moist; noncalcareous; clear, smooth lower boundary.

$B_{2ca}$ 14 to 22 inches, dark-brown (7.5YR 4/2, dry; 3/2, moist) loam; moderate, medium, prismatic structure that breaks to moderate, medium, subangular blocky; hard when dry, friable when moist; slightly calcareous, with weak, lime mycelia; clear, smooth lower boundary.

$C_{ca1}$ 22 to 28 inches, brown or dark-brown (7.5YR 5/4, dry; 3/2, moist) sandy loam; massive to single grain (structureless); loose when dry or moist; strongly calcareous; clear, smooth lower boundary.

$C_{ca2}$ 28 to 32 inches, light-brown or dark-brown (7.5YR 6/4, dry; 4/2, moist) loamy sand; massive to single grain (structureless); loose when dry or moist; strongly calcareous; abrupt lower boundary.

D 32 to 60 inches, pinkish-white or pinkish-gray (7.5YR 8/2, dry; 7/2, moist) loam (strongly calcareous lacustrine material); massive; hard when dry, friable when moist.

Runoff is slow, and the permeability of the subsoil is moderate.

**Portales fine sandy loam, 0 to 2 percent slopes** (Pa).—This soil is in capability unit IIIe-1 (climatic zone 3), in capability unit IVe-1 (climatic zone 4), and in the Sandy Plains range site.

**Portales loam, 0 to 2 percent slopes** (Pb).—Except that it has a surface layer of loam, this soil is like the one described for the Portales series. It is in capability unit IIIc-1 (climatic zone 3), in capability unit IVc-1 (climatic zone 4), and in the Plains Upland range site.

## Potter Series

In the Potter series are very shallow, loamy soils that overlie hard caliche. The light-colored surface soil is about 2 inches thick. It grades to light-colored, loamy material that is underlain by caliche at depths of 6 to 15 inches. The soils show little profile development.

These soils have formed in very limy plains outwash. Beds of caliche keep most roots from penetrating deeply,

but water moves downward through fractures in the caliche. The vegetation consists of a mixture of mid and short grasses and a few shrubs and palatable herbs.

The Potter soils are shallower than the Mansker soils.

Typical profile of Potter loam (300 feet west and 200 feet south of the northeastern corner of sec. 22, T. 7 N., R. 30 E.):

$A_1$ 0 to 2 inches, light brownish-gray or brown (7.5YR 6/2, dry; 4/2, moist) loam; moderate, fine, granular structure; slightly hard when dry, very friable when moist; strongly calcareous; gradual, smooth lower boundary.

AC 2 to 5 inches, light brownish-gray or light-brown (7.5YR 6/3, dry; 4/3, moist) loam; weak, medium, subangular blocky structure; hard when dry, very friable when moist; strongly calcareous; gradual, smooth lower boundary.

$C_1$ 5 to 11 inches, light-brown or brown (7.5YR 6.5/4, dry; 5/4, moist) loam; weak, coarse, subangular blocky structure that breaks to weak, coarse, granular; slightly hard when dry, very friable when moist; there is much wormworking in this horizon; strongly calcareous; gradual, smooth lower boundary.

$C_2$ 11 to 13 inches, pink or light-brown (7.5YR 7/4, dry; 6/4, moist) loam; massive; hard when dry, friable when moist; 50 to 60 percent of this horizon consists of partly weathered fragments of caliche; strongly calcareous; gradual, smooth lower boundary.

D 13 inches +, white caliche that is partly weathered and partly indurated.

The color of the Potter soils ranges from light brownish gray to very dark brown. These soils occur mainly on slopes of more than 5 percent, and, as a result, runoff is rapid. The water-storage capacity is low; consequently, runoff is increased during prolonged heavy storms. In the more nearly level areas, runoff is slight. Here, many fragments of rock, mixed with the cover of grass, tend to check the velocity of the runoff water and to keep erosion at a minimum. The soils are droughty because they are shallow and contain many fragments of caliche.

**Potter loam** (Pd).—This level to strongly sloping soil has many angular fragments of caliche throughout its profile. It is in capability unit VIs-2 (climatic zones 3 and 4) and in the Shallow Upland range site.

**Potter fine sandy loam** (Pc).—In contrast to Potter loam, the surface layer of this soil contains sand. In addition, there are fewer angular fragments of caliche in the uppermost 2 or 3 inches. This nearly level to strongly rolling soil is in capability unit VIs-2 (climatic zones 3 and 4) and in the Shallow Upland range site.

## Pullman Series

In the Pullman series are deep, loamy soils that have an angular blocky subsoil. These, the most extensive soils in the survey area, lie above the caprock and occur throughout the uplands.

The surface layer is loamy and is generally about 8 inches thick. The dark-brown, blocky subsoil of heavy clay loam is about 24 inches thick. A zone of soft caliche normally begins at depths between 36 and 60 inches.

These soils have formed in calcareous loamy plains outwash that may have been reworked by wind. The native vegetation consists mainly of buffalograss and blue grama.

The Pullman soils are not so red and are slightly finer textured throughout the profile than the Amarillo soils.

Typical profile of Pullman loam (300 feet east and 600 feet south of the northwestern corner of sec. 6, T. 6 N., R. 32 E., see table 9 for analyses):

$A_+$ 0 to 1 inch, brown or dark-brown (7.5YR 5/4, dry; 3/2, moist) fine sand recently deposited by the wind; single grain (structureless); loose; noncalcareous; abrupt, smooth lower boundary.

$A_1$ 1 to 4 inches, dark grayish-brown or very dark grayish-brown (10YR 4/2, dry; 3/2, moist) loam; very thin, platy to weak, fine, granular structure; soft when dry, very friable when moist; noncalcareous; abrupt, smooth lower boundary.

$A_3$ 4 to 8 inches, dark-brown (10YR 4/2.5, dry; 3/3, moist) loam; weak, very fine, granular structure; slightly hard when dry, friable when moist; noncalcareous; clear, smooth lower boundary.

$B_1$ 8 to 15 inches, dark-brown (10YR 4/2.5, dry; 3/3, moist) clay loam; weak, medium to fine, subangular blocky structure; slightly hard when dry, friable when moist; thin, patchy clay films on aggregate faces; noncalcareous; clear, smooth lower boundary.

$B_{21}$ 15 to 25 inches, dark-brown (10YR 4/2.5, dry; 3/2.5, moist) clay loam; strong, fine, prismatic structure that breaks to strong, medium to fine, angular blocky; very hard when dry, moderately friable when moist; strong, continuous clay films; noncalcareous; gradual, smooth lower boundary.

$B_{22}$ 25 to 33 inches, dark-brown (10YR 4/3, dry; 3/3, moist) clay loam; strong, fine, prismatic structure that breaks to strong, medium to fine, angular blocky; very hard when dry, moderately friable when moist; thin, patchy clay films on aggregates; clear, smooth lower boundary.

$B_3$ 33 to 40 inches, brown or reddish-brown (7.5YR 4.5/4, dry; 5YR 4/4, moist) clay loam; moderate, medium to fine subangular blocky structure; hard when dry, friable when moist; slightly calcareous, with abundant mycelia of lime; diffuse lower boundary.

$C_1$ 40 to 60 inches, light reddish-brown or yellowish-red (5YR 6/4, dry; 4/6, moist, clay loam; very weak, medium to fine, subangular blocky structure; hard when dry, friable when moist; thin, patchy clay films on aggregate faces; slightly calcareous, with a few, fine to medium, soft concretions and veins of lime; abrupt, wavy lower boundary.

$C_{ca1}$ 60 to 84 inches, reddish-yellow or yellowish-red (5YR 6/6, dry; 5/6, moist) loam; massive; strongly calcareous, with light-gray concretions of lime; diffuse lower boundary.

$C_{ca2}$ 84 to 120 inches, similar to horizon immediately above but has less mottlings and fewer concretions.

The surface soil is 2 to 15 inches thick, depending on the amount of erosion that has taken place. In many areas it consists of remnants of the A horizon mixed with material from the upper part of the B horizon. This $A_p$ horizon, or plow layer, has lost much of its fine-textured material through blowing. Eroded phases were not mapped, however, because it is difficult to distinguish between the original and present A horizons and because the depth to the $B_2$ horizon varies. The depth to the $C_{ca}$ horizons ranges from 36 to 60 inches. Surface runoff is medium, and the permeability of the subsoil is slow. The soils are seldom wet to a great depth, except in years when precipitation is much higher than normal.

**Pullman loam, 0 to 2 percent slopes** (Pe).—This is one of the better soils for cultivated crops. It is used largely to grow winter wheat (fig. 4). For dryland farming, this soil is in capability unit IIIc-1 (climatic zone 3) and in capability unit IVc-1 (climatic zone 4). For

***Figure 4.*—Cattle grazing winter wheat on an area of Pullman loam. Besides supplying good winter grazing, this crop provides excellent protection against wind erosion.**

irrigation farming, it is in capability unit IIe-2. Range management is discussed under the Plains Upland range site.

**Pullman loam, 2 to 5 percent slopes** (Pf).—Except that all the horizons are slightly thinner, the profile of this soil is similar to that described for the series. For dryland farming, this soil is in capability unit IIIc-1 (climatic zone 3) and in capability unit IVc-1 (climatic zone 4). It is in the Plains Upland range site.

## Pullman-Mansker Complexes

These extensive soil complexes are made up of many spots of shallow, calcareous Mansker soils intermingled with the deeper, darker, noncalcareous Pullman soils. Between 10 and 15 percent of the acreage of these complexes is composed of the Mansker soils. In a bare field the soils of these complexes present a spotted aspect.

A profile of a Pullman soil is described under the Pullman series, and one of the Mansker soils is described under the Mansker series. In these complexes, the Pullman soils are generally shallower than the soil given in the profile description. The depth to the layer of caliche ranges from 28 to 36 inches.

Good yields of wheat are produced on these soils, but, when the areas are cultivated, wind erosion is a more severe hazard than on the Pullman loams that are mapped separately.

**Pullman-Mansker loams, 0 to 2 percent slopes** (Pg).—These soils are used for both irrigated and dryland crops. For dryland farming, they are in capability unit IIIc-1 (climatic zone 3) and in capability unit IVc-1 (climatic zone 4). For irrigation farming, they are in capability unit IIs-2; for grazing, they are in the Plains Upland range site.

**Pullman-Mansker loams, 2 to 5 percent slopes** (Ph).—These soils are gently sloping. For dryland farming, they are in capability unit IIIc-1 (climatic zone 3) and in capability unit IVc-1 (climatic zone 4). They are in the Plains Upland range site.

## Regnier Series

The Regnier series consists of shallow soils that have formed on beds of reddish-brown siltstone, loamstone, or sandstone. The reddish-brown surface soil, about 4 inches thick, grades to weathered bedrock. No subsoil has developed.

These soils have formed in silty or loamy material weathered from redbeds. Bedrock occurs at a depth of less than 18 inches. The vegetation consists mainly of tobosagrass, blue grama, and alkali sacaton.

The Regnier soils are less clayey, are shallower to bedrock, and have less profile development than the Hassell soils.

Only one member of the Regnier series, Regnier silt loam, is mapped in the survey area. All of this soil lies below the caprock.

Typical profile of Regnier silt loam (1,400 feet south and 300 feet east of the northwestern corner of sec. 20, T. 5 N., R. 27 E.):

$A_1$ 0 to 2 inches, reddish-brown or dark reddish-brown (5YR 3.5/3, dry; 3/3, moist) silt loam; weak, platy structure in upper inch and weak, fine, granular structure in lower inch; soft when dry, very friable when moist; calcareous; clear, smooth lower boundary.

AC 2 to 6 inches, reddish-brown or dark reddish-brown (2.5YR 4.5/4, dry; 3.5/4, moist) loam or very fine sandy loam; weak, medium, subangular blocky structure; hard when dry, friable when moist; calcareous; gradual, smooth lower boundary.

C 6 to 12 inches, reddish-brown (2.5YR 5/4, dry; 4/4, moist) loam or very fine sandy loam; massive (structureless) to very weak, medium, subangular blocky structure; hard when dry, friable when moist; calcareous; gradual, smooth lower boundary.

D 12 to 22 inches, reddish-brown (2.5YR 5/4, dry; 4/4, moist), platy beds of siltstone, loamstone, and sandstone.

Because they are shallow, these soils have a low available moisture-storage capacity. Runoff is rapid, especially if the range is in poor condition. The permeability of the subsoil is slow.

**Regnier silt loam** (Ra).—Most of this soil is nearly level to gently sloping, but in small areas there are stronger slopes. Many areas are barren. Under favorable conditions, fair stands of galleta and sacaton grasses grow on this soil, which is too shallow and too dry for the growth of cultivated crops. This soil is in capability unit VIe-2 (climatic zone 5) and in the Heavy Slopes range site.

## Riverwash

**Riverwash** (Rb).—This miscellaneous land type consists of material recently deposited in the streambeds of the larger intermittent drainageways. It lies below the caprock in the western part of the survey area. The texture of the material ranges from sand to clay, depending on the source. From 85 to 90 percent of the material is sandy. No vegetation is growing on Riverwash, and this land type is of no value for crops or range. It is in capability unit VIIIw-1 (climatic zone 5).

## Rough Broken and Stony Land

**Rough broken and stony land** (Rc).—This miscellaneous land type lies on the steeper parts of the escarpment; here, the High Plains break off to the valleys in the northern and western parts of the survey area. Many sandstone boulders and stones are on the surface.

The surface soil, typically a grayish-brown loam, is underlain by a subsoil of clay loam. Sandstone or shale generally begins at depths between 10 and 40 inches.

Only a small amount of water runs off this land. Side-oats grama, galleta, and blue grama and such shrubs as mountain-mahogany provide good forage. Juniper is common. Grazing is good, even though slopes range from 5 to 20 percent. This land type is in capability unit VIIe-2 (climatic zone 5) and in the Breaks range site.

## San Jose Series

The San Jose soils are deep, reddish brown, calcareous, and loamy. They occur below the caprock on flood plains and alluvial fans.

The surface soil is thin and ranges from sandy to loamy in texture. The underlying material consists of stratified sands and clays that have been washed from soils on and below the escarpment. The San Jose soils show little or no profile development. Within short distances, the texture of the soil differs, and buried soils commonly occur. Both mid and short grasses grow on these soils; the short grasses increase if the condition of the range declines.

The San Jose soils are redder, are more stratified, and lack the gravel common to the Ima soils. They are not so well developed as the La Lande soils.

Typical profile of San Jose fine sand, moderately deep over sand (1,200 feet north of the southwestern corner of sec. 10, T. 5 N., R. 27 E.):

$A_1$ 0 to 6 inches, brown or dark-brown (7.5YR 5.5/3, dry; 3.5/3, moist) fine sand; single grain; loose when dry or moist; strongly calcareous; clear, smooth lower boundary.

$C_1$ 6 to 11 inches, reddish-brown or dark reddish-brown (5YR 5/3, dry; 3.5/3, moist), heavy fine sandy loam; massive; slightly hard when dry, very friable when moist; strongly calcareous; clear, smooth lower boundary.

$C_2$ 11 to 15 inches, reddish-brown (5YR 5/3, dry; 4/3, moist) loam stratified with light clay loam; massive (structureless) to very weak, coarse, subangular blocky structure; hard when dry, friable when moist; strongly calcareous; gradual, smooth lower boundary.

$A_{1b}$ 15 to 20 inches, reddish-brown or dark reddish-brown (5YR 5/3, dry; 3/3.5, moist), light clay loam stratified with lenses of loam and very fine sandy loam; moderate, medium, prismatic structure breaking to moderate, medium, subangular blocky; hard when dry, friable when moist; strongly calcareous; gradual, smooth lower boundary.

$D_1$ 20 to 42 inches, reddish-brown (5YR 5/3, dry; 4/3, moist) loamy fine sand; massive; slightly hard when dry, very friable when moist; strongly calcareous; gradual, smooth lower boundary.

$D_2$ 42 to 66 inches, reddish-brown (5YR 5/3, dry; 4/3, moist) fine sand single grain; soft when dry, very friable when moist; strongly calcareous.

Runoff is slow, and the permeability of the subsoil is moderately rapid. Soil material is still being deposited; consequently, many areas are bare and others have only a cover of annual weeds and grasses. The soils are not suited to cultivation and provide only fair grazing.

**San Jose fine sand, moderately deep over sand, 0 to 2 percent slopes** (Sa).—This soil occurs in small drainageways and on the more nearly level parts of the valley floor. It is in capability unit VIe-1 (climatic zone 5) and in the Sandy Plains range site.

**San Jose fine sand, moderately deep over sand, 2 to 5 percent slopes** (Sb).—This gently sloping soil is in capability unit VIe-1 (climatic zone 5) and in the Sandy Plains range site.

## Springer Series

The Springer series consists of brown to reddish-brown, sandy soils that have a moderately developed subsoil. In this survey area the soils occur both above and below the caprock.

The surface soil is 8 to 10 inches thick. The moderately developed subsoil of fine sandy loam is about 28 inches thick and is underlain by a weak zone of lime.

The parent material is made up mainly of calcareous, sandy plains outwash. In areas below the caprock, it consists of plains outwash mixed with materials weathered from sandstone, caliche, and shale. The soils have formed under grass, mainly side-oats grama, needle-and-thread, little bluestem, and blue grama. Soapweed and sand sagebrush are common.

The Springer soils are sandier and not so well developed as the Amarillo soils.

Typical profile of S ger fine sandy loam (50 feet west and 150 feet north of the southeastern corner of sec. 32, T. 5 N., R. 30 E.):

$A_{11}$ 0 to 2 inches, brown or dark-brown (7.5YR 4/4, dry; 3/2, moist) fine sandy loam; weak to moderate, thick, platy structure that breaks to moderate, very fine, granular; soft when dry, very friable when moist; noncalcareous; clear, smooth lower boundary.

$A_{12}$ 2 to 8 inches, reddish-brown or dark reddish-brown (5YR 4/4, dry; 3/4, moist) fine sandy loam; weak, coarse, subangular blocky structure that breaks to weak, fine, granular; slightly hard when dry, very friable when moist; noncalcareous; gradual, smooth lower boundary.

$B_1$ 8 to 19 inches, reddish-brown or dark reddish-brown (5YR 4/4, dry; 3/4, moist) fine sandy loam; weak, coarse, prismatic structure that breaks to weak, medium, subangular blocky; slightly hard when dry, very friable when moist; very thin and very patchy clay films on aggregates; noncalcareous; gradual, lower boundary.

$B_{21}$ 19 to 26 inches, yellowish-red (5YR 4/6, dry; 3/6, moist), heavy fine sandy loam; weak to moderate, coarse, prismatic structure that breaks to weak to moderate, coarse and medium, subangular blocky; hard when dry, friable when moist; a few, thin, patchy clay films on aggregates; noncalcareous; gradual, smooth lower boundary.

$B_{3ca}$ 26 to 36 inches, yellowish-red (5YR 5/6, dry; 4/6, moist) fine sandy loam; very weak, coarse, subangular blocky structure; slightly hard when dry, very friable when moist; noncalcareous but contains a few, very small, soft concretions of calcium carbonate; gradual, smooth lower boundary.

$C_{ca}$ 36 to 42 inches, yellowish-red (5YR 5/6, dry; 4/6, moist), light fine sandy loam or loamy fine sand; massive; slightly hard when dry, very friable when moist; noncalcareous, but contains a few, small, soft concretions of calcium carbonate.

Soft caliche occurs below a depth of 60 inches. Runoff is slow, and the permeability of the subsoil is moderately rapid. Wind erosion is often a serious problem.

**Springer fine sandy loam, 0 to 2 percent slopes** (Sc).—This soil is best kept in grass, but it can be used for sorghums, under dryland farming, or for irrigated crops. For dryland farming, it is in capability unit IVe-2 (climatic zones 3 and 4). For irrigation farming, it is in capability unit IIIe-5. This soil is in the Sandy Plains range site.

**Springer fine sandy loam, 2 to 5 percent slopes** (Sd).—This soil can either be kept in grass or used to grow sorghums under dryland farming. It is in capability unit IVe-2 (climatic zones 3 and 4) and in the Sandy Plains range site.

**Springer fine sandy loam, valleys, 0 to 5 percent slopes** (Se).—All of this soil occurs below the caprock. Its profile is slightly redder and has a thinner surface layer than the profile described for the Springer series. Because it occurs in an area of limited rainfall, this soil is not suitable for cultivation. It is in capability unit VIe-1 (climatic zone 5) and in the Sandy Plains range site.

**Springer loamy fine sand, 0 to 5 percent slopes** (Sf).—The profile of this soil is sandier throughout than the profile described for the Springer series. The surface layer of loamy fine sand ranges from 2 to 15 inches in thickness. Wind erosion is a serious hazard. In some places the surface layer has been removed by wind, and, in others, small dunes have formed. Wind erosion accounts for the variation in the thickness of the surface soil. This soil is in capability unit VIe-4 (climatic zones 3 and 4) and in the Deep Sands range site.

## Spur Series

In the Spur series are dark-brown, weakly developed soils that lie along intermittent drainageways in the uplands. The silty surface soil is about 3 or 4 inches thick and is underlain by a thick subsoil of brown clay loam that has a subangular blocky structure.

The parent material consists of brown, silty material that has been washed into the drainageways from the surrounding uplands. These soils have formed under grass.

The Spur soils are less clayey than the Church soils. They are not so sandy as the Drake soils.

Only one member of the Spur series was mapped in this survey area.

Typical profile of Spur silt loam (400 feet north and 150 feet west of the southeastern corner of sec. 15, T. 5 N., R. 29 E.):

A 0 to 4 inches, dark-brown (7.5YR 4/2, dry; 3/2, moist) silt loam; weak, fine, subangular blocky structure; soft when dry or moist; noncalcareous; abrupt, smooth lower boundary.

B 4 to 42 inches, dark-brown (7.5YR 4/2, dry; 3/2, moist) clay loam; moderate, fine, subangular blocky structure; hard when dry, firm when moist; moderately calcareous; diffuse lower boundary.

C 42 to 60 inches, brown to dark-brown (7.5YR 5/3, dry; 4/3, moist) silt loam; massive; soft; strongly calcareous.

Some areas, especially rangelands, are flooded occasionally, but most irrigated areas have been protected by dikes and diversions. The permeability of the subsoil is slow.

**Spur soils** (Sg).—These soils have slopes of 0 to 5 percent. In areas that can be irrigated and protected from flooding, excellent yields of crops are produced. For irrigation farming, these soils are in capability unit IIe-1. Nonirrigated areas are in capability unit VIw-2 (climatic zones 3 and 4). These soils are in the Plains Bottom-lands range site.

## Stony Rough Land

These miscellaneous land types—Stony rough land, mixed materials, and Stony rough land, Potter materials—occur below the caprock on the steep slopes of the escarpment.

**Stony rough land, mixed materials** (Sh).—This mapping unit occurs on slopes of various gradients. The thin mantle of stony soil varies in thickness. In some places it is as much as 10 inches thick; and in other places the mantle of soil is lacking and caliche, sandstone, shale, and limestone are exposed (fig. 5). This mapping unit is in capability unit VIIe-2 (climatic zones 4 and 5) and in the Breaks range site.

**Stony rough land, Potter materials** (Sk).—This mapping unit is made up of caliche and limestone rock and, in places, a thin layer of soil mixed with many fragments of caliche. Many slopes are greater than 15 percent, and water erosion is common and severe. This mapping unit is in capability unit VIIe-2 (climatic zones 4 and 5) and in the Breaks range site.

## Tivoli Series

The Tivoli series consists of deep, loose sands that show little profile development. The sands have been reworked by wind and occur on dunelike topography.

The surface soil of brown fine sand is underlain by reddish-brown sand. This grades downward to yellowish-red fine sand that extends to depths of more than 60 inches.

The Tivoli soils have developed in loose sands. They have formed under a grass vegetation of sand bluestem, little bluestem, yellow Indiangrass, and giant dropseed.

These soils are sandier and lack the profile development of the Springer soils. They are sandier and redder than the Drake soils.

*Figure 5.*—Stony rough land, mixed materials, is in the Breaks range site.

Only one member of the Tivoli series, Tivoli fine sand, is mapped in this survey area.

Typical profile of Tivoli fine sand (1,400 feet north and 1,000 feet west of the southeastern corner of sec. 33, T. 5 N., R. 27 E.):

$A_1$ 0 to 9 inches, brown or dark-brown (7.5YR 5/4, dry; 4/4, moist) fine sand or loamy fine sand; single grain; loose when dry or moist; noncalcareous; gradual, smooth lower boundary.

AC 9 to 22 inches, reddish-brown (5YR 5/4, dry; 4/4, moist) fine sand; very weak, coarse, subangular blocky structure; slightly hard when dry, very friable when moist; noncalcareous; diffuse, smooth lower boundary.

C 22 to 60 inches, yellowish-red (5YR 5/6, dry; 4/6, moist) fine sand; single grain; loose when dry or moist; noncalcareous.

These loose sands absorb the limited amount of precipitation as it falls. The permeability of the subsoil is very rapid.

**Tivoli fine sand** (Ta).—This soil occurs below the caprock in the southwestern part of the survey area. If the grass is grazed too closely or destroyed, there is an extreme hazard of wind erosion. This soil is in capability unit VIIe-1 (climatic zone 5) and in the Deep Sands range site.

## Tucumcari Series

In the Tucumcari series are deep, reddish-brown, loamy soils that have a well-developed subsoil and a prominent zone of lime. They occur below the caprock in the western part of the survey area.

The thin, loamy surface soil is about 4 inches thick. It is underlain by a thick clay loam subsoil of subangular blocky structure. The lime zone is at the base of the subsoil. Soft caliche begins at depths of 24 to 30 inches.

The parent material has weathered from sandstone and shale of the redbeds and was washed into the valleys. The vegetation consists mainly of short grasses, a few mesquite bushes, and pricklypear cactuses. Snakeweed invades overgrazed areas.

The Tucumcari soils have formed in alluvial material, whereas the Amarillo soils have formed in plains outwash. Unlike the Alama soils, the Tucumcari soils have a zone of soft caliche.

Typical profile of Tucumcari loam (50 feet east and 300 feet north of the southwestern corner of sec. 9, T. 5 N., R. 27 E.):

$A_1$ 0 to 4 inches, reddish-brown or dark reddish-brown (5YR 3.5/3, dry; 3/3, moist) loam; moderate, thin, platy structure that breaks to moderate, fine, granular; slightly hard when dry, very friable when moist; calcareous; clear, smooth lower boundary.

$B_1$ 4 to 7 inches, dark reddish-gray or dark reddish-brown (5YR 4.5/2, dry; 3/2.5, moist) clay loam; weak to moderate, medium, prismatic structure that breaks to moderate, very coarse, granular and very fine, subangular blocky; hard when dry; very friable when moist; calcareous; clear, smooth lower boundary.

$B_2$ 7 to 14 inches, reddish-brown or dark reddish-brown (5YR 4.5/3, dry; 3.5/3, moist) clay loam; moderate, coarse, prismatic structure that breaks to moderate, coarse, subangular blocky; hard when dry, friable when moist; thin, nearly continuous clay films on aggregates; calcareous; gradual, smooth lower boundary.

$B_{3ca1}$ 14 to 23 inches, reddish-brown (5YR 5/3, dry; 4/3, moist) clay loam; weak, coarse, subangular blocky structure; hard when dry, friable when moist; thin, patchy clay films on aggregates; strongly calcareous; lime visible, principally as small, myceliated seams; gradual, smooth lower boundary.

$B_{3ca2}$ 23 to 30 inches, reddish-brown (5YR 5/3, dry; 4/3, moist) clay loam; weak, coarse, subangular blocky structure; hard when dry, friable when moist; strongly calcareous, with lime occurring principally as soft concretions; gradual, smooth lower boundary.

$C_{ca}$ 30 to 36 inches, pinkish-white or pink (7.5YR 8/2, dry; 7/3, moist) loam; massive; hard when dry, friable when moist; strongly calcareous, with lime visible in finely divided form and as soft concretions; gradual, smooth lower boundary.

C 36 to 60 inches, light reddish-brown or reddish-brown (5YR 6/4, dry; 4/4, moist) sandy clay loam; massive; hard when dry, friable when moist; strongly calcareous; lime accumulations, but much less than in the horizon immediately above.

The loam type, the only soil type of the Tucumcari series mapped in the survey area, grades toward silt loam. When the range is in poor condition, runoff is medium. The permeability of the subsoil is slow.

**Tucumcari loam, 0 to 2 percent slopes** (Tb).—This soil occurs only in climatic zone 5 and is in capability unit VIc-1. It is in the Plains Upland range site.

**Tucumcari loam, 2 to 5 percent slopes** (Tc).—In most places the profile of this soil is slightly shallower to caliche than the profile described for the Tucumcari series. This soil is in capability unit VIc-1 (climatic zone 5) and in the Plains Upland range site.

# *Use and Management of Soils*

This section has four main parts. The first explains the system of land capability grouping used by the Soil Conservation Service. In the second part the use and management of the soil are discussed for both dryland and irrigation farming. The third part gives estimated yields for cultivated crops. The fourth discusses range management.

## Capability Groups of Soils

Capability grouping is a system of classification used to show the relative suitability of soils for crops, grazing, forestry, and wildlife. It is a practical grouping based on the management needs of the soils and on their responses to management.

In the capability grouping used by the Soil Conservation Service, soils are placed in eight general capability classes. The classes in this broad grouping are identified by Roman numerals. Soils in classes I through IV can be used for crops. They are also suitable for use as grassland. Soils with limitations that make cultivation too hazardous are placed in classes V through VII. These soils are suitable only for permanent vegetation that can be used for grazing and as a cover for wildlife. The limitations of the soils of class VIII are so great that they have no productive use other than to provide recreational areas, watershed protection, and cover for wildlife.

All of the soils in one class have limitations and management problems of about the same degree. The soils within a class may be of different kinds, however, and,

therefore, they will have different kinds of limitations. The dominant kind of limitation is indicated by one of four subclasses, as follows: (e) Susceptibility to erosion, either through wind or water; (w) excess water as the result of seepage, a high water table, or floods; (s) low moisture-holding capacity, very high bulk density (impervious soil), excess amount of gravel or stones, shallow depth, or other unfavorable characteristics; and (c) climate, chiefly extremes in precipitation or temperature. No subclasses are recognized in class I.

A capability unit consists of soils that are similar in the kind of management they need, in risk of erosion, and in general suitability for use.

The soils of the Southwest Quay Area have been placed in capability units for both dryland and irrigation farming. All of the soils mapped have been placed in classes, subclasses, and units for dryland farming, but only those soils on which irrigation is feasible have been placed in classes, subclasses, and units for irrigation farming. There are no soils in classes I or V in the survey area.

#### CAPABILITY CLASSIFICATION FOR DRYLAND FARMING

Class III.—Soils suited to tilled crops or grass but having severe limitations that restrict choice of plants, require special conservation practices, or both.
- Subclass IIIe: Soils severely limited by risk of erosion if they are cultivated without protection.
  - Unit:
    - IIIe-1: Deep and moderately deep soils with moderately sandy surface soils and loamy subsoils.
- Subclass IIIc: Soils severely limited by climate.
  - Unit:
    - IIIc-1: Deep and moderately deep soils with loamy surface soils and medium to moderately fine textured subsoils.

Class IV.—Soils suited to tilled crops or grass but having very severe limitations that restrict choice of plants, require very careful management, or both.
- Subclass IVe: Soils very severely limited by risk of erosion if cultivated without protection.
  - Unit:
    - IVe-1: Deep and moderately deep soils with sandy surface soils and medium-textured subsoils.
    - IVe-2: Deep soils with sandy surface soils and subsoils.
    - IVe-3: Shallow and moderately deep soils with calcareous sandy and loamy surface soils.
- Subclass IVc: Soils very severely limited by climate for uses that require cultivation.
  - Unit:
    - IVc-1: Deep and moderately deep soils with loamy surface soils and medium to moderately fine textured subsoils.

Class VI.—Soils severely limited and not suitable for cultivation but suitable for rangeland.
- Subclass VIe: Soils highly susceptible to erosion.
  - Unit:
    - VIe-1: Shallow to deep, nearly level to sloping, dominantly sandy soils.
    - VIe-2: Shallow to moderately deep, nearly level to gently sloping soils that have medium-textured to fine-textured surface soils and slowly permeable subsoils.
    - VIe-3: Moderately deep, limy, nearly level to sloping, loamy soils.
    - VIe-4: Deep, nearly level to gently sloping, sandy soils.
- Subclass VIw: Soils limited by excessive wetness.
  - Unit:
    - VIw-1: Clayey soils that have very slow permeability and are subject to flooding.
    - VIw-2: Loamy soils of bottom lands that are subject to flooding.
- Subclass VIc: Soils severely limited by unfavorable climate.
  - Unit:
    - VIc-1: Loamy soils that are nearly level to sloping.
- Subclass VIs: Soils having unfavorable physical characteristics.
  - Unit:
    - VIs-1: Nearly level to gently sloping soils that are shallow or that contain scab spots high in alkali.
    - VIs-2: Shallow and very shallow soils with low moisture-holding capacity.

Class VII.—Soils very severely limited and not suitable for cultivation but suitable for grazing with strict limitations on use.
- Subclass VIIe: Soils subject to rapid erosion if not protected.
  - Unit:
    - VIIe-1: Deep, very sandy soils.
    - VIIe-2: Steep, stony, rough broken land.

Class VIII.—Soils not suitable for cultivation or grazing but suitable for wildlife, recreational areas, or watershed protection.
- Subclass VIIIw: Land type in streambeds; subject to floods.
  - Unit:
    - VIIIw-1: Riverwash.

#### CAPABILITY CLASSIFICATION FOR IRRIGATION FARMING

Class II.—Soils having some limitations that reduce choice of plants or that require some conservation practices.
- Subclass IIe: Nearly level soils that are likely to erode if not protected.
  - Unit:
    - IIe-1: Deep soils that have dark-brown and reddish-brown, medium-textured, noncalcareous surface soils underlain by moderately permeable subsoils.
    - IIe-2: Deep, hardland soil with a medium-textured, noncalcareous surface layer and a slowly permeable, moderately fine textured subsoil.
- Subclass IIs: Soils in which the root zone is limited by soft caliche at depths of 20 to 36 inches.
  - Unit:
    - IIs-1: Nearly level, loamy soils with moderately permeable subsoils.

IIs-2: Nearly level, loamy soils with slowly permeable subsoils.

Class III.—Soils that have severe limitations that reduce the choice of plants, or that require special conservation practices, or both.

Subclass IIIe: Gently sloping soils that will erode if not protected.

Unit:

IIIe-2: Deep, hardland soil with a reddish-brown, medium-textured, noncalcareous surface soil and a moderately permeable subsoil; occurs on slopes of 2 to 5 percent.

IIIe-3: Deep, reddish-brown soil with a reddish-brown fine sandy loam surface layer and a sandy clay loam subsoil; occurs on slopes of 0 to 2 percent.

IIIe-4: Moderately deep soils with fine sandy loam surface layers and moderately permeable subsoils; occur on slopes of 0 to 5 percent.

IIIe-5: Deep soil with a fine sandy loam surface soil and a rapidly permeable subsoil; occurs on slopes of 0 to 2 percent.

Class IV.—Soils having very severe limitations that restrict the choice of plants, or that require very careful management, or both.

Subclass IVe: Soils severely limited by risk of erosion if they are not protected.

Unit:

IVe-4: Moderately deep, limy, fine sandy loam soil on slopes of 2 to 5 percent.

Subclass IVs: Soils severely limited by low available moisture capacity or a shallow root zone.

Unit:

IVs-1: Loamy soil that is shallow over caliche.

IVs-2: Moderately fine textured soil underlain by a very slowly permeable subsoil.

IVs-3: Very limy fine sandy loams and loams that are moderately deep to soft caliche; occur on slopes of 0 to 2 percent.

## Management of Cultivated Soils

In the survey area, variation in the amount of effective rainfall is the main factor to be considered in determining how the soils can be used and managed. The survey area has been divided into three climatic zones, as shown in figure 6. This figure also shows the areas where irrigation farming is practiced.

Table 2 shows the climatic zone in which each soil occurs, as well as the capability unit and range site in which each soil has been placed. As shown in this table, a soil that occurs in more than one climatic zone may also be in more than one capability unit.

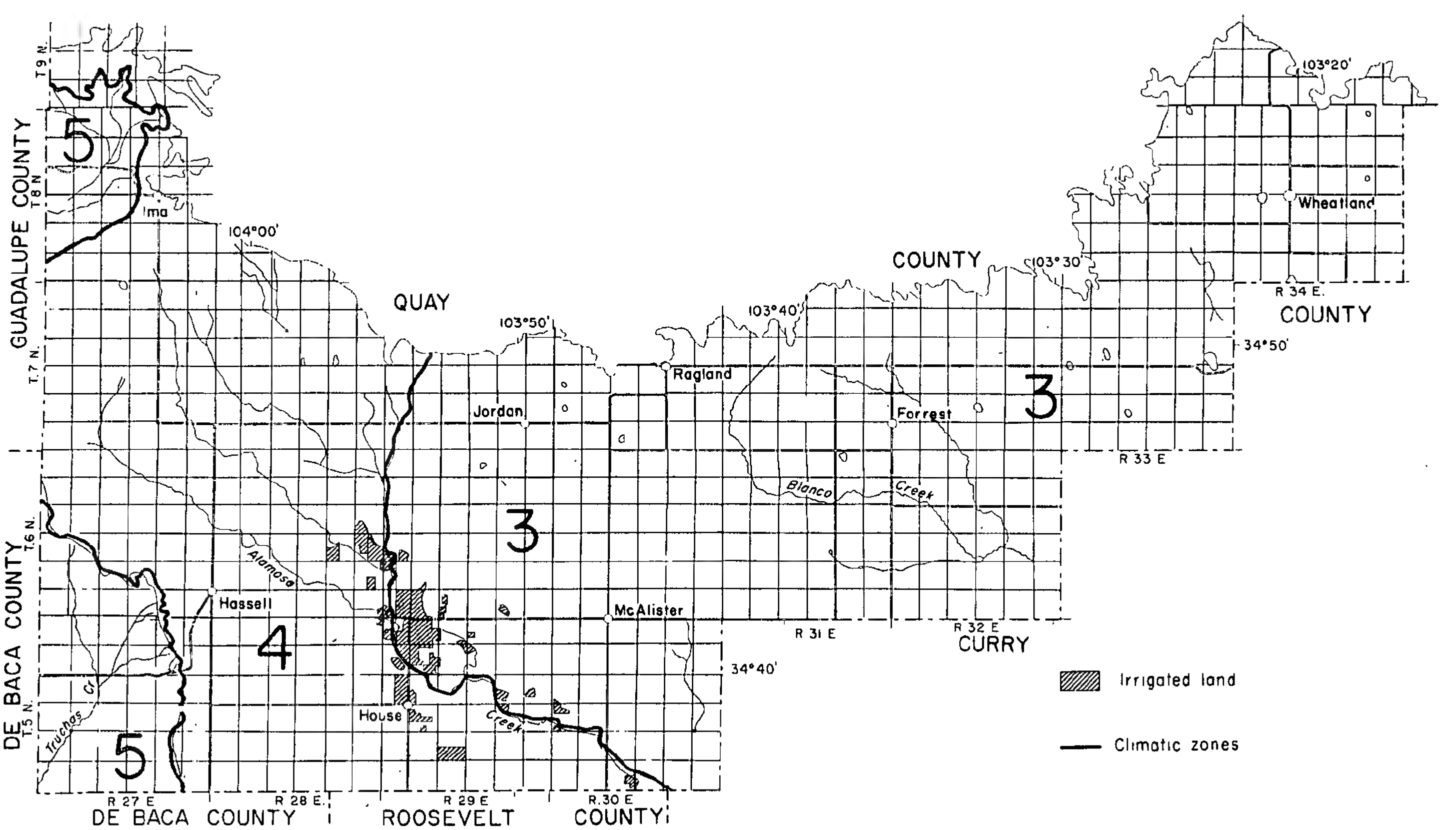


*Figure 6.*—**Climatic zones and irrigated areas in the Southwest Quay Area. Climatic zone 3 receives the greatest amount of effective precipitation; zone 4, a lesser amount; and zone 5, the least. The irrigated areas, which occur near the town of House, are shown by shading.**

TABLE 2.—*Capability units and range sites of the soils*

| Soil | Capability units | | | | Range site |
|---|---|---|---|---|---|
| | Climatic zone 3 | Climatic zone 4 | Climatic zone 5 | Irrigated land | |
| Alama loam, 0 to 2 percent slopes | | | VIc-1 | | Plains Upland. |
| Alama loam, 2 to 5 percent slopes | | | VIc-1 | | Plains Upland. |
| Alama silt loam, 0 to 2 percent slopes | | | VIc-1 | | Plains Upland. |
| Alama silt loam, 2 to 5 percent slopes | | | VIc-1 | | Plains Upland. |
| Amarillo fine sandy loam, 0 to 2 percent slopes | IIIe-1 | IVe-1 | | IIIe-3 | Sandy Plains. |
| Amarillo fine sandy loam, 2 to 5 percent slopes | IIIe-1 | IVe-1 | | | Sandy Plains. |
| Amarillo loam, 0 to 2 percent slopes | IIIc-1 | IVc-1 | | IIe-1 | Plains Upland. |
| Amarillo loam, 2 to 5 percent slopes | IIIc-1 | IVc-1 | | IIIe-2 | Plains Upland. |
| Amarillo loam, valleys, 0 to 2 percent slopes | | | VIc-1 | | Plains Upland. |
| Amarillo loam, valleys, 2 to 5 percent slopes | | | VIc-1 | | Plains Upland. |
| Arch fine sandy loam | VIe-1 | VIe-1 | | | Sandy Plains. |
| Arch loam | VIs-1 | VIs-1 | | | Plains Upland. |
| Arch loamy fine sand | VIe-1 | VIe-1 | | | Sandy Plains. |
| Arvana fine sandy loam, shallow, 0 to 2 percent slopes | VIe-1 | VIe-1 | | | Sandy Plains. |
| Arvana fine sandy loam, shallow, 2 to 5 percent slopes | VIe-1 | VIe-1 | | | Sandy Plains. |
| Arvana loam, shallow, 0 to 2 percent slopes | VIs-1 | VIs-1 | | IVs-1 | Plains Upland. |
| Arvana loam, shallow, 2 to 5 percent slopes | VIs-1 | VIs-1 | | | Plains Upland. |
| Church clay loam | VIw-1 | VIw-1 | | IVs-2 | Heavy Bottom lands. |
| Clovis-Amarillo fine sandy loams, 0 to 5 percent slopes | IIIe-1 | IVe-1 | | IIIe-4 | Sandy Plains. |
| Clovis-Amarillo loams, 0 to 2 percent slopes | IIIc-1 | IVc-1 | | IIs-1 | Plains Upland. |
| Clovis-Amarillo loams, 2 to 5 percent slopes | IIIc-1 | IVc-1 | | | Plains Upland. |
| Clovis-Amarillo loams, valleys, 0 to 2 percent slopes | | | VIc-1 | | Plains Upland. |
| Clovis-Amarillo loams, valleys, 2 to 5 percent slopes | | | VIc-1 | | Plains Upland. |
| Drake fine sandy loam, 2 to 10 percent slopes | VIe-1 | VIe-1 | | | Sandy Plains. |
| Drake loamy fine sand, 2 to 10 percent slopes | VIIe-1 | VIIe-1 | | | Deep Sands. |
| Hassell loam, 2 to 5 percent slopes | | | VIe-2 | | Heavy Slopes. |
| Ima gravelly loam, light-colored variant, 2 to 5 percent slopes | | | VIc-1 | | Plains Upland. |
| Ima gravelly loam, light-colored variant, 5 to 10 percent slopes | | | VIc-1 | | Plains Upland. |
| Ima loam, 0 to 2 percent slopes | | | VIc 1 | | Plains Upland. |
| Ima loam, 2 to 5 percent slopes | | | VIc-1 | | Plains Upland. |
| La Lande loam, 0 to 2 percent slopes | | | VIc-1 | | Plains Upland. |
| La Lande loam, 2 to 5 percent slopes | | | VIc-1 | | Plains Upland. |
| Larimer gravelly loam | VIs-2 | VIs-2 | | | Shallow Upland. |
| Lofton clay loam | | VIw-2 | | | Plains Bottom lands. |
| Mansker fine sandy loam, 0 to 2 percent slopes | IVe-3 | VIe-1 | | IVs-3 | Sandy Plains. |
| Mansker fine sandy loam, 2 to 5 percent slopes | VIe-1 | VIe-1 | | IVe-4 | Sandy Plains. |
| Mansker fine sandy loam, 5 to 10 percent slopes | VIe-1 | VIe-1 | | | Sandy Plains. |
| Mansker loam, 0 to 2 percent slopes | IVe-3 | IVe-3 | | IVs-3 | Plains Upland. |
| Mansker loam, 2 to 5 percent slopes | VIe-3 | VIe-3 | | | Plains Upland. |
| Mansker loam, 5 to 10 percent slopes | VIe-3 | VIe-3 | | | Plains Upland. |
| Manwood-Pullman loams | | VIs-1 | | | Plains Upland. |
| Montoya silty clay loam, 0 to 2 percent slopes | | | VIw-1 | | Heavy Bottom lands. |
| Montoya silty clay loam, 2 to 5 percent slopes | | | VIe-2 | | Heavy Slopes. |
| Newkirk sandy loam, 2 to 10 percent slopes | | | VIe-1 | | Sandy Plains. |
| Portales fine sandy loam, 0 to 2 percent slopes | IIIe-1 | IVe-1 | | | Sandy Plains. |
| Portales loam, 0 to 2 percent slopes | IIIc-1 | IVc-1 | | | Plains Upland. |
| Potter fine sandy loam | VIs-2 | VIs 2 | | | Shallow Upland. |
| Potter loam | VIs-2 | VIs-2 | | | Shallow Upland. |
| Pullman loam, 0 to 2 percent slopes | IIIc-1 | IVc-1 | | IIe-2 | Plains Upland. |
| Pullman loam, 2 to 5 percent slopes | IIIc-1 | IVc-1 | | | Plains Upland. |
| Pullman-Mansker loams, 0 to 2 percent slopes | IIIc-1 | IVc-1 | | IIs-2 | Plains Upland. |
| Pullman-Mansker loams, 2 to 5 percent slopes | IIIc-1 | IVc-1 | | | Plains Upland. |
| Regnier silt loam | | | VIe-2 | | Heavy Slopes. |
| Riverwash | | | VIIIw-1 | | (1). |
| Rough broken and stony land | | | VIIe-2 | | Breaks. |
| San Jose fine sand, moderately deep over sand, 0 to 2 percent slopes. | | | VIe-1 | | Sandy Plains. |
| San Jose fine sand, moderately deep over sand, 2 to 5 percent slopes. | | | VIe-1 | | Sandy Plains. |
| Springer fine sandy loam, 0 to 2 percent slopes | IVe-2 | IVe-2 | | IIIe-5 | Sandy Plains. |
| Springer fine sandy loam, 2 to 5 percent slopes | IVe-2 | IVe-2 | | | Sandy Plains. |
| Springer fine sandy loam, valleys, 0 to 5 percent slopes | | | VIe-1 | | Sandy Plains. |
| Springer loamy fine sand, 0 to 5 percent slopes | VIe-4 | VIe-4 | | | Deep Sands. |
| Spur soils | VIw-2 | VIw-2 | | IIe-1 | Plains Bottom lands. |
| Stony rough land, mixed materials | | VIIe-2 | VIIe-2 | | Breaks. |
| Stony rough land, Potter materials | | VIIe-2 | VIIe-2 | | Breaks. |
| Tivoli fine sand | | | VIIe-1 | | Deep Sands. |
| Tucumcari loam, 0 to 2 percent slopes | | | VIc-1 | | Plains Upland. |
| Tucumcari loam, 2 to 5 percent slopes | | | VIc-1 | | Plains Upland. |

[1] Wasteland that is of no value as range.

The climatic zones are based on a crop-moisture index[1] that is a modification of Thornthwaite's Precipitation-Effectiveness Index (P. E.). The State is divided into seven climatic zones, of which zone 1 gets the most rainfall, and zone 7, the least. This survey area is in zones 3, 4, and 5. This zoning system gives special emphasis to effective spring precipitation. Zone 3 receives the most effective precipitation, and zone 5 receives the least. Zone 4 differs from zone 3 in that crop failures are more common and the surface cover is more difficult to maintain. In zone 5, all of which occurs below the caprock, there is not enough moisture to grow crops. Here, the lack of cover and organic matter make the soil more likely to erode or deteriorate.

The combination of adverse climate and other limiting factors in this survey area is such that conservation of moisture and control of soil blowing are basic needs on all the soils used for irrigation or dryland farming. The practices appropriate for conservation of moisture and control of blowing are summarized in the following paragraphs. These practices, in combination with the more specialized practices suggested under the headings, Management of Capability Units (dryland farming), and Management of Capability Units (irrigation farming), are the basis for efficient management of the soils in the survey area.

### CONSERVING MOISTURE

Use of level, open-end, broad-based terraces, combined with contour tillage, is one of the most effective ways of conserving moisture on the more sloping soils. The terraces slow runoff water and give it more time to soak into the soil. The terraces prevent some water erosion, and, by saving moisture, they increase the growth of vegetation. The vegetation, in turn, helps to check soil blowing.

Fallowing builds up moisture in soils used for dryland crops. The moisture stored in the soil while it is without a growing cover is available when a crop is planted. Fallow land needs the protection of sorghum stubble or other heavy crop residue. Otherwise, it will blow.

Eradication of weeds is necessary if crops are to have full advantage of the moisture in the soils.

### CONTROLLING SOIL BLOWING

The practices effective in controlling soil blowing are (1) keeping crops or crop residues on the soil continuously, (2) stubble-mulch tillage, and (3) emergency tillage.

*Continuous cover.*—Keeping a continuous cover of growing crops or crop residues on the soil is the most effective means of controlling wind erosion (fig. 7). When there is enough moisture, wheat that is sown in fall will furnish enough cover to prevent the soil from blowing. A good cover of either wheat or grain-sorghum stubble will also check wind erosion (fig. 8).

*Stubble-mulch tillage.*—This is a method of cultivating with a subtillage sweep in such a way that the crop stubble is only slightly disturbed. This kind of tillage is proving highly successful in the production of wheat (fig. 9). However, the one-way diskplow is still used more commonly by wheat farmers of the survey area.

*Figure 7.*—**This cover of wheat protects the soil against wind erosion during the windy season.**

One-way tillage is easier and quicker than stubble-mulch tillage, but it is likely to result in the formation of a tillage pan and to increase the risk of erosion if the soil is plowed soon after the wheat is harvested.

Studies conducted on Pullman soils on the High Plains in west Texas show that higher average yields are obtained consistently where stubble-mulch tillage is practiced than where one-way tillage is used. Stubble-mulch tillage allows more of the crop residue to remain on the soil. This additional organic matter helps to improve the structure of the soil and to increase its capacity to store moisture while fallow. Stubble-mulch tillage also helps to prevent the surface soil from being sealed by the impact of raindrops or by melting snow. The soil thus remains more permeable, and less moisture evaporates.

The main disadvantages of stubble-mulch tillage are that deep-furrow seed drills must be used for planting when the amount of residue exceeds 2,000 pounds per

*Figure 8.*—**Stubble of grain sorghum helps prevent wind erosion on this soil.**

[1] MAKER, H. J., and DREGNE, H. E. CLIMATIC ZONES IN NEW MEXICO. N. Mex. Agr. Expt. Sta. Press Bul. 1057. 1951.

*Figure 9.*—**Subtillage sweeps, 30 inches long, will cut the roots of the stubble but leave the stubble above the surface.**

acre. Also, attachments are needed to prevent the stubble from obstructing planting.

*Emergency tillage.*—If his wheat or stubble is grazed too closely, the farmer must use emergency tillage to prevent wind erosion. At the first sign of erosion, he needs to "streak" his field. This consists of operating one or more chisels or listers crosswise to the direction of the prevailing winds and deep enough to bring up large clods from the heavy subsoil. The furrows are spaced at different widths, or from 3 feet to 12 or 15 feet apart. If the first tillage fails to check soil movement, the farmer repeats the operation by cultivating between the previous furrows. If the hazard of erosion is extremely severe, the field is listed deep or chiseled solid—that is, none of the soil originally at the surface is left exposed.

### Management of capability units (dryland farming)

This subsection describes and suggests dryland management for the soils in capability classes III and IV. The soils are described by capability units, which are groups of soils that need about the same kind of management and show similar response to management. Soils of classes VI through VIII are not described here because they are not suitable for cultivation. They are discussed in the subsection, Range Management.

As heretofore mentioned, a soil may be in more than one climatic zone, and, consequently, may be in more than one capability unit. The climatic zone for every soil is shown in table 2, and the zones are also marked on the index to map sheets.

Under dryland farming, conservation of water is the first requirement, and prevention of soil blowing is the second. All farming operations must be based on the need for retaining water in the soil. On stronger slopes, terracing and contour farming help to conserve water. Fallowing and control of weeds will conserve water in all the soils. The time of tillage and seeding is important. If there is enough moisture in the soil, wheat should be seeded between the 1st and 15th of September. Frequently, a difference of a day or so in seeding time will determine whether you get a crop or a failure. The growth of weeds must be controlled promptly to conserve moisture.

A cropping system is needed that will keep the pale western cutworm from multiplying. In the past decade, cutworms have destroyed crops in several years. Various means of eradicating these pests have been tried without success. Once the cutworm population reaches the outbreak stage, little can be done to save a growing crop. A cropping system consisting of 1 year each of grain sorghums, fallow, and wheat will keep damage to a minimum. Except when there is a serious outbreak of cutworms, keeping the soil in wheat for 1 year and letting it lie fallow the next will reduce the damage done by cutworms.

#### CAPABILITY UNIT IIIe-1

The soils of the sandy row-crops lands make up this capability unit. They are moderately deep and deep, moderately sandy soils that have medium-textured loamy subsoils. The following soils are in this capability unit:

Amarillo fine sandy loam, 0 to 2 percent slopes.
Amarillo fine sandy loam, 2 to 5 percent slopes.
Clovis-Amarillo fine sandy loams, 0 to 5 percent slopes.
Portales fine sandy loam, 0 to 2 percent slopes.

Grain sorghums are the principal crop grown. If soil blowing is controlled properly, winter wheat and other small grains can be grown successfully. To control soil blowing—

1. Use stubble-mulch tillage.
2. Fallow the fields in summer only when there is enough crop residue or stubble to protect the soil from blowing. Start this practice in spring after the weeds begin to grow.
3. When row crops are harvested, leave a stubble 8 to 12 inches high; the height needed depends on the distance between rows.
4. If emergency tillage is needed because of lack of cover, use only a lister-type plow.

*Alternative use.*—These soils can produce good to excellent native grass. See the Sandy Plains range site for suggestions on the proper management of rangeland.

#### CAPABILITY UNIT IIIc-1

In this capability unit are deep and moderately deep, loamy soils that have compact, medium to moderately fine textured subsoils. The slopes range from 0 to 5 percent. The soils are:

Amarillo loam, 0 to 2 percent slopes.
Amarillo loam, 2 to 5 percent slopes.
Clovis-Amarillo loams, 0 to 2 percent slopes.
Clovis-Amarillo loams, 2 to 5 percent slopes.
Portales loam, 0 to 2 percent slopes.
Pullman loam, 0 to 2 percent slopes.
Pullman loam, 2 to 5 percent slopes.
Pullman-Mansker loams, 0 to 2 percent slopes.
Pullman-Mansker loams, 2 to 5 percent slopes.

These soils are used principally to grow winter wheat, although barley, rye, and grain sorghums can be grown satisfactorily. Conserving soil moisture and controlling soil blowing are the principal management problems. To do this—

1. Use stubble-mulch tillage.
2. Leave a stubble at least 12 inches high after sorghums are harvested.

3. For summer fallow, delay tillage until weeds start using moisture, usually between April 15 and May 1.
4. Use terraces and contour cultivation.
5. Resort to emergency tillage when there is not enough crop growth or crop residue to prevent soil blowing.

*Alternative use.*—Temporary pastures of sudangrass can be planted for summer grazing. After the end of the grazing period, leave 6 inches of stubble on soil that has been drilled and 8 to 12 inches on soil that has been listed.

For management of areas in native pasture, see the Plains Upland range site.

#### CAPABILITY UNIT IVe-1

Except for being in climatic zone 4 instead of zone 3, the soils of this capability unit are the same as those of capability unit IIIe-1. Since climatic zone 4 is drier than zone 3, low yields, crop failures, and serious erosion are more common than on the same soils in capability unit IIIe-1. The soils in capability unit IVe-1 are:

Amarillo fine sandy loam, 0 to 2 percent slopes.
Amarillo fine sandy loam, 2 to 5 percent slopes.
Clovis-Amarillo fine sandy loams, 0 to 5 percent slopes.
Portales fine sandy loam, 0 to 2 percent slopes.

The conservation practices described for soils of capability unit IIIe-1 apply to these soils; but erosion-control measures, such as emergency tillage and the use of cover crops, may have to be used more frequently.

*Alternative use.*—For areas under native grass, see the Sandy Plains range site for suggestions on management.

#### CAPABILITY UNIT IVe-2

The soils of this capability unit have deep, sandy loam surface layers and slightly finer textured subsoils. Their water-holding capacity is low, and they are rapidly permeable. The following soils are in this capability unit:

Springer fine sandy loam, 0 to 2 percent slopes.
Springer fine sandy loam, 2 to 5 percent slopes.

Soil blowing is a serious problem. The soils are best kept in native grass, but they can be used for sorghums or sudangrass if a protective cover crop or crop residues are kept on them at all times. Leave at least a 12-inch stubble for protection against soil blowing.

*Alternative use.*—For areas under native grass, see the Sandy Plains range site for suggestions on management.

#### CAPABILITY UNIT IVe-3

In this capability unit are soils with little or no profile development. The texture of the surface layer is loam and fine sandy loam, and the soils are strongly calcareous throughout. The following soils are in capability unit IVe-3:

Mansker loam, 0 to 2 percent slopes.
Mansker fine sandy loam, 0 to 2 percent slopes.

These soils take water rapidly, and there is little runoff. As a result, yields of wheat are sometimes as high as those obtained on the deeper soils of capability unit IIIc–1, which are subject to more runoff. On Mansker soils grain sorghums are often damaged by chlorosis, which is a yellowing of the green parts of the plant. Good yields of sorghums are obtained on nonchlorotic areas.

Under dryland farming, these calcareous soils are highly susceptible to blowing. To control erosion—

1. Keep growing crops, a cover crop, or crop residues on the soil at all times. Leave at least an 8- to 12-inch stubble; this should never be grazed.
2. If emergency tillage is needed because of inadequate cover, use only a lister-type plow.
3. Till and seed on the contour.

*Alternative use.*—For range management of Mansker loam, 0 to 2 percent slopes, see the Plains Upland range site, and for Mansker fine sandy loam, 0 to 2 percent slopes, see the Sandy Plains range site.

#### CAPABILITY UNIT IVc-1

The soils of this capability unit are the same soils as those in capability unit IIIc-1, except that they are in climatic zone 4 instead of zone 3. Because climatic zone 4 is drier than zone 3, long-term average yields are lower and crop failures are more frequent. The soils in this unit are:

Amarillo loam, 0 to 2 percent slopes.
Amarillo loam, 2 to 5 percent slopes.
Clovis-Amarillo loams, 0 to 2 percent slopes.
Clovis-Amarillo loams, 2 to 5 percent slopes.
Portales loam, 0 to 2 percent slopes.
Pullman loam, 0 to 2 percent slopes.
Pullman loam, 2 to 5 percent slopes.
Pullman-Mansker loams, 0 to 2 percent slopes.
Pullman-Mansker loams, 2 to 5 percent slopes.

The same conservation practices can be applied to the soils of this capability unit as are used for those of unit IIIc–1. To protect them against soil blowing, emergency tillage may be needed more often and cover crops may be necessary. If the soils of this capability unit are cultivated, extreme care must be used to prevent soil blowing.

*Alternative use.*—These soils, if in native sod, should not be cultivated. They are best used as permanent rangeland and are in the Plains Upland range site.

### *Management of capability units (irrigation farming)*

The soils of the survey area suitable for irrigation farming are listed by capability units in this subsection. These soils are in classes II, III, and IV. Soils in classes VI through VIII are not suitable for irrigation farming; these and the other soils are listed by range site, in the subsection, Range Management.

Approximately 6,000 acres along Alamosa Creek is used for irrigation farming. (See figure 6.) Here, there is enough underground water for irrigation. Wells drilled in this area normally produce 400 to 500 gallons of water per minute. Because the supply of underground water is limited to areas along Alamosa Creek, little additional acreage can be brought under irrigation.

To obtain adequate heads for proper irrigation, farmers use ponds or overnight storage tanks. In some places the flow from two or more wells is combined to furnish enough water for one field. The length of the irrigation runs varies according to differences in the soils and to the amount of water available.

In irrigated areas keep the soil covered with residue or a growing crop to prevent soil blowing and thereby keep the fields level. When sorghums are cut, leave a

12-inch stubble to control blowing. Before the planting of the next crop, work the residue into the soil to maintain tilth and to increase the content of organic matter.

Commercial fertilizer is needed to get high yields of crops. Successful farmers use 60 pounds of available nitrogen per acre for row crops and small grains. Studies made by the Northeastern Experiment Station near Tucumcari show that grain sorghums do not respond to commercial fertilizer for 2 years if they follow alfalfa grown on soil that has received 480 pounds of available phosphorus per acre before planting time. Other studies show that if alfalfa has not been grown during the previous 2 years, application of 80 pounds of nitrogen per acre for wheat and 120 pounds per acre for grain sorghums will prove profitable. For high yields, alfalfa requires phosphatic fertilizer. Annual applications of 80 pounds of available phosphorus may be made, or a preplanting application of 480 pounds per acre, enough to last for the duration of the stand, may be used.

#### CAPABILITY UNIT IIe-1

In general, the soils of this capability unit have dark-brown and reddish-brown, medium-textured, noncalcareous surface layers of good tilth. They are alluvial soils on the bottom lands along Alamosa Creek. The soils are variable in texture, but, in general, air and water move slowly through the subsoils of dark-brown clay loam. In a small hardland area, the surface layers consist of deep, reddish-brown loam and the subsoils are medium textured and take water readily. The following soils are in this capability unit:

Amarillo loam, 0 to 2 percent slopes.
Spur soils.

These are among the most productive irrigated soils in the survey area. All crops suited to the climate will grow on them. Excellent yields of sorghums, alfalfa, and wheat are obtained. A cropping sequence consisting of alfalfa for 3 or 4 years and small grains and row crops for 3 or 4 years is suitable.

These soils resist blowing. If necessary, the cloddy subsoil can be brought to the surface easily through emergency tillage.

The root zone of these soils holds 5 or 6 inches of readily available moisture for alfalfa. This is enough moisture for the plant to maintain the necessary rapid growth during about 3 weeks in midsummer; then, irrigation is necessary. The intake of water is about 1 inch per hour or nearly twice that of Pullman loam, 0 to 2 percent slopes, in capability unit IIe-2. Loss of water in ditches is moderate, or about 2 to 4 gallons a minute per 100 feet of ditch.

In leveling, grades of 0.1 to 0.3 percent will permit adequate penetration of water and efficient irrigation. If the grade is steeper, avoid excessive loss of water below the root zone by using shorter irrigation runs.

#### CAPABILITY UNIT IIe-2

Pullman loam, 0 to 2 percent slopes, is in this capability unit. It is a brown, deep, hardland soil having a medium-textured, noncalcareous surface layer that averages 6 inches in thickness. The subsoil is moderately fine textured and compact; consequently, air and water move slowly. Below a depth of 2½ feet, the soil is loamy and air and water move readily. In most places layers of soft caliche are at a depth of 4½ feet.

Under irrigation, wheat, grain sorghums, and alfalfa produce high yields. Good tilth can be maintained by using a cropping sequence consisting of alfalfa for 3 or 4 years and small grains and row crops for 3 or 4 years.

Because the soil dries out slowly after irrigation, it is easily compacted by livestock and farm machinery. A good cover of crop residue generally will control soil blowing, but if emergency tillage is needed, chiseling will bring clods from the subsoil to the surface.

This deep soil has excellent capacity to hold moisture readily available to plants; 5 to 6 inches of moisture can be stored between the surface and a depth of 5 feet. The irrigation intake averages only half an inch per hour because the subsoil is very tight. On slopes of more than 0.1 percent, moisture usually does not penetrate adequately and there is some loss of tailwater. Tailwater ditches help recover the waste water. Little water is lost in the irrigation ditches, normally less than 1 gallon a minute per 100 feet of ditch.

For deep penetration of moisture, level this soil to a grade of about 0.05 percent. A uniform grade is needed to keep the water from ponding and drowning out alfalfa and similar crops. An alternative practice is to level the soil to grades ranging from 0.1 to 0.5 percent and to use a longer irrigation run. The length of the run will depend on the size of the streamflow. On slopes of more than 0.5 percent, bench terraces can be laid out or the flow of irrigation water can be adjusted to obtain the proper penetration of water without too much loss of soil

#### CAPABILITY UNIT IIs-1

Clovis-Amarillo loams, 0 to 2 percent slopes, belong to this capability unit. These are nearly level, loamy soils that have moderately permeable subsoils underlain by accumulations of lime; soft caliche occurs at depths of 24 to 30 inches.

These soils are used for all crops suited to the area. Good yields can be obtained, but they are somewhat lower than those obtained on the deeper soils of capability unit IIe-1. The soils are similar to the soils in capability unit IIs-2 except that they have medium-textured subsoils. The intake rate of water is about 1 inch per hour, whereas the soils of capability unit IIs-2 have an intake rate of one-half inch per hour.

Because plant roots penetrate the layer of soft caliche very poorly, if at all, these soils can hold only 4 or 5 inches of moisture available for the rapid growth of plants. This is about 1 inch less than the deeper soils of capability unit IIe-1; therefore, the areas must be irrigated more frequently. Loss of water in ditches is moderate, or from 2 to 4 gallons per minute for 100 feet of ditch. In leveling the areas, leave at least a foot of soil above the layer of soft caliche.

#### CAPABILITY UNIT IIs-2

Pullman-Mansker loams, 0 to 2 percent slopes, are in capability unit IIs-2. The soils are similar to Pullman loam, 0 to 2 percent slopes, described in capability unit IIe-2, but the layer of soft caliche is closer to the

surface, typically at a depth of 2½ feet. In many spots the surface soils are calcareous and more susceptible to blowing than those in noncalcareous areas.

Yields of wheat and sorghums are slightly lower than those obtained on the soil of capability unit IIe-2.

Because their roots, at best, only poorly penetrate the layer of soft caliche, the soil holds about 1 inch less of water than Pullman loam, 0 to 2 percent slopes, in capability unit IIe-2. Thus, the roots of a mature crop, as alfalfa, can pull only 4 or 5 inches of moisture to maintain rapid growth.

In bench leveling slopes of nearly 2 percent, leave at least a foot of soil above the layer of soft caliche.

#### CAPABILITY UNIT IIIe-2

The only soil in this capability unit is Amarillo loam, 2 to 5 percent slopes. It is a reddish-brown, medium-textured soil of the hardland. Except for having stronger slopes, it is similar to the soils of capability unit IIe-1.

Bench leveling, with grades of up to 0.3 percent, is suitable. Rodents should be eradicated to prevent irrigation ditches and border ridges next to benches from breaking. Where bench leveling is not practiced, keep water flowing in the furrows at a nonerosive speed.

#### CAPABILITY UNIT IIIe-3

Amarillo fine sandy loam, 0 to 2 percent slopes, is in this capability unit. It is a deep soil that has a reddish-brown fine sandy loam surface layer about 6 inches thick. The subsoil consists of reddish-brown sandy clay loam through which air and water move readily. The layer of soft caliche generally occurs at a depth of 4 feet.

Yields of alfalfa are very good, and yields of grain sorghums and wheat are good. Since the soil is subject to blowing, maintain alfalfa for 4 years or as long as a good stand remains; then, grow row crops for 2 years.

Because of its sandy surface layer, this soil holds about 1 inch less of readily available moisture than the soils of capability unit IIe-1. To maintain rapid growth of plants, plan to irrigate 3 or 4 days earlier on this soil. This sandy soil may take water faster than the loamy soils. Where the soil is firm, the water-intake rate may be as much as 2 inches per hour, but if the soil is compacted, the intake rate may be as slow as 1 inch per hour. Loss of water in the ditches is high, or from 5 to 10 gallons a minute per 100 feet of ditch. Much water can be saved through the use of lined ditches or underground pipe.

A good residue helps to control soil blowing. But if emergency tillage is needed, chiseling will bring cloddy subsoil to the surface. Grazing of the crop residues may cause wind erosion.

The soil particles are well graded; consequently, the soil is readily compacted if tilled when it is so wet that it will form a durable ball when molded in the hands.

If the soil is leveled to a grade of 0.1 to 0.3 percent, moisture will penetrate adequately. Where the grades are stronger, adjust the flow of water so that it will not be erosive. Nevertheless, a fairly large flow is needed in each furrow. With adequate flow, water will cover the furrow in a reasonable length of time and there will be no loss of water below the root zone, especially in the area next to the ditch.

#### CAPABILITY UNIT IIIe-4

Clovis-Amarillo fine sandy loams, 0 to 5 percent slopes, are in this capability unit. The soils have surface layers of reddish-brown fine sandy loam. They are similar to Amarillo fine sandy loam, 0 to 2 percent slopes, in capability unit IIIe-3, but the soft caliche is closer to the surface, or at depths of between 24 and 36 inches.

Because the roots of crops penetrate the soft caliche poorly, these soils have a shallower root zone than the Amarillo fine sandy loam of capability unit IIIe-3. Only 3½ to 4½ inches of moisture is readily available for the rapid growth of plants. These soils need irrigation about once every 2 weeks in midsummer, in contrast to once every 3 weeks for the deep soils of capability unit IIe-1.

Alfalfa and grain sorghums, the common crops, produce moderate yields. The cropping sequence is similar to that used on the Amarillo fine sandy loam of capability unit IIIe-3. Although these soils hold less moisture, they take water rapidly. As a result, efficient irrigation is a problem. In places where border irrigation is used, it may be necessary to shorten the irrigation run or to increase the flow. Plant nutrients readily leach from these soils if they are overirrigated.

Where bench leveling is done on the steeper grades, leave at least 12 inches of soil above the layer of soft caliche. Keep the border ridges of benches in good condition because these soils erode very rapidly if water breaks through.

#### CAPABILITY UNIT IIIe-5

Springer fine sandy loam, 0 to 2 percent slopes, is in capability unit IIIe-5. It has a surface layer of reddish-brown fine sandy loam and a subsoil of fine sandy loam.

This soil is less fertile, more readily leached of plant nutrients, and lower in crop yields than Amarillo fine sandy loam, 0 to 2 percent slopes, of capability unit IIIe-3. Sorghums and alfalfa are the principal crops.

The areas are subject to soil blowing. Unfortunately, chiseling does not bring stable clods to the surface. When this soil is used for row crops, a good, ungrazed residue will help control blowing.

This soil holds only 3 or 4 inches of moisture readily available for the rapid growth of plants. It may need irrigation as often as once every 10 to 14 days. The intake of water is often 2 inches per hour. Loss of 10 gallons of water a minute per 100 feet of ditch may be expected. Underground pipes help reduce loss of water.

#### CAPABILITY UNIT IVe-4

Mansker fine sandy loam, 2 to 5 percent slopes, is in this capability unit. Except for having stronger slopes, the soil is similar to those in capability unit IVs-3. In general, the slopes range from 2 to 5 percent. Small areas next to the stream channels or around playas have stronger slopes.

Yields of crops are similar to those obtained on the soils of capability unit IVs-3. Alfalfa or other perennial plants should be maintained as long as a good stand remains.

Water adequately penetrates the soil if the irrigation stream is of the proper size. A fairly large, nonerosive flow of water is needed for efficient irrigation.

Bench leveling, with grades up to 0.3 percent, can be practiced. In most places the degree of cut is limited by the shallowness of the soil, and, therefore, the benches will be narrow. Soil blowing is likely to make the surface uneven.

#### CAPABILITY UNIT IVs-1

Arvana loam, shallow, 0 to 2 percent slopes, is in capability unit IVs-1. It is shallow over hard, fractured caliche that, in most places, is at depths between 15 and 20 inches. The surface layer is loam, and the shallow subsoil is reddish-brown sandy clay loam to light clay loam through which water and air move readily.

Yields of alfalfa, wheat, and sorghums are low to fair. Alfalfa may be grown for 4 years, or as long as a good stand remains. This is followed by 2 years of row crops.

This soil is droughty and has a capacity for holding only 2½ to 3½ inches of readily available moisture. In small areas only 6 inches of soil overlies the caliche. In these very droughty spots the soil holds only about 1 inch of readily available moisture.

In midsummer rapidly growing crops need irrigation about every 10 days. The intake of water averages 1 inch per hour. Loss of water in the ditches averages 4 gallons a minute per 100 feet of ditch.

Leveling should be limited to smoothing operations sufficient to permit getting the water over the land. A large flow of irrigation water in short runs helps to prevent water from penetrating beneath the root zone and into the caliche. Lined ditches reduce loss of water in the ditches.

#### CAPABILITY UNIT IVs-2

Church clay loam is in capability unit IVs-2. It has a surface soil and upper subsoil of dark grayish-brown clay loam. Air and water move slowly through the soil. Between depths of 20 and 36 inches, there is gray, strongly calcareous, clayey material; roots penetrate this layer poorly or not at all. This soil is on low terraces in the bottoms of former lakes. The slopes are less than 1 percent.

Fair yields of small grains and sorghums are obtained. Yields of alfalfa are low. Growing alfalfa and sweetclover and incorporating residues from grain sorghums will improve the workability of the soil.

This soil remains wet longer after irrigation than most soils; it tends to become compacted if tilled or trampled by farm animals when it is wet. It should not be tilled when it is wet enough to be worked into a durable ball in the hands.

This soil holds from 3½ to 5 inches of readily available moisture. The intake of water is about half an inch per hour. Little water, less than a gallon a minute per 100 feet of ditch, is lost in the ditches.

Moisture usually penetrates best if the soil is leveled to a uniform grade of 0.05 percent and long irrigation runs are used. In areas that are not leveled to this grade, a small flow of water applied for a long period will insure adequate penetration.

#### CAPABILITY UNIT IVs-3

The soils of this capability unit are moderately deep to soft caliche. They have surface layers of brown, calcareous loam and fine sandy loam. Their subsoils are medium textured and are readily permeable to air and water. The following soils are in capability unit IVs-3:

Mansker loam, 0 to 2 percent slopes.
Mansker fine sandy loam, 0 to 2 percent slopes.

Yields of alfalfa and wheat are fair, but yields of sorghums are low. Grain sorghums often turn yellow because of a lack of iron. The tilth and structure of the soil are best maintained by growing alfalfa for 4 years, or as long as a good stand remains, and following with 2 years of row crops.

These soils are subject to blowing and are best plowed after the windy season. Chiseling the subsoil does not produce stable clods, although some temporary clods can be brought to the surface. When emergency tillage is needed to control soil blowing, the fields can be roughened with a lister.

Mansker loam, 0 to 2 percent slopes, holds from 3 to 4 inches of readily available moisture, and Mansker fine sandy loam, 0 to 2 percent slopes, holds about half an inch less. To maintain rapid growth of plants in midsummer, farmers usually need to irrigate about once every 2 weeks. The intake of water often is nearly 2 inches per hour. Loss of water in the ditches is high, or from 7 to 10 gallons of water a minute per 100 feet of ditch.

In leveling the areas, leave at least 1 foot of soil over the soft caliche. Irrigation grades of 0.3 percent or less are satisfactory. A large, nonerosive flow of water will quickly cover the area and, in places near the ditch, help prevent water from penetrating beneath the root zone.

## Estimated Yields

The first part of this section gives estimated yields of wheat and sorghums under dryland farming and explains the relationship between crop yields and effective precipitation. The second part gives estimated yields of wheat, sorghums, and alfalfa on the irrigated soils of the survey area.

### *Yields under dryland farming*

Yields of wheat and sorghum depend mainly on the amount of precipitation and the time of year it falls. The soils never produce as much as they could if moisture were adequate. Differences among soils, therefore, are far less important than differences in rainfall. An area of soil in the eastern part of the survey area (climatic zone 3) receives more rainfall, on the average, than an area of the same soil in the western part (climatic zone 4). The area in climatic zone 3, therefore, can be expected to produce higher yields over a long period of years.

The pattern of rainfall in the survey area is erratic. Effective moisture, the rainfall that comes at a time when it can benefit a crop, has much greater effect on yields than the total rainfall in a year. During 1946 and 1947, for example, the total rainfall in this area was about 28 inches. But of this, nearly 16 inches fell during the 10-month period from July 1946 to May 1947. Practically all of this moisture benefited the fall-sown wheat crop, which averaged 13 bushels per acre. On the other hand, in 1951 and 1952 the total rainfall was nearly

26 inches. But only slightly more than 10 inches of this fell from July 1951 to May 1952, and, as a result, the wheat crop failed. In this area, one heavy rain may account for as much as one-third of the total yearly rainfall. The amount of annual rainfall, therefore, does not necessarily indicate how much winter wheat will yield.

As indicated in the foregoing, only the effective precipitation can be considered in estimating crop yields. The precipitation must come at a time when it can benefit a crop and must be an amount large enough to contribute to the store of soil moisture. Small amounts of precipitation quickly evaporate and add little or no moisture to the soil. The minimum amount of effective daily precipitation is one-half inch or more, between May 1 and September 30, and one-fourth inch, between October 1 and April 30. During the period from May 1 through September 30, daily rainfall of a little more than one-fourth inch is considered effective when more than one-half inch of rainfall occurs on the preceding or following day.

The relation of yield to effective precipitation is such that the following yields of fall-sown wheat may be obtained on a soil that is wet to a depth of 24 inches when the crop is planted:

| Effective precipitation (October through June): | *Bushels per acre* |
|---|---|
| Less than 4 inches | 0 (failure). |
| 4 to 7¾ inches | 5.6. |
| 7¾ inches or more | 13.0 or more. |

If there has been considerably more than 7¾ inches of effective moisture in the period October through June, yields of 30 to 35 bushels of wheat have been obtained.

It is estimated that effective rainfall, for the period from October 1 through June 30, will be less than 4 inches 1 year out of every 3; 4 to 7¾ inches, 1 year out of 3; and 7¾ inches or more, 1 year out of 3.

Estimated yields for grain sorghums vary in relation to effective precipitation that falls in the period March 1 through September 30. The following yields have been obtained:

| Effective precipitation: | *Pounds per acre* |
|---|---|
| 6 inches or less | 0 (failure). |
| 6 to 10 inches | 600. |
| 10 inches or more | 1,000 to 2,000. |

Where there has been considerably more than 10 inches of effective precipitation, yields of 3,500 to 4,000 pounds of sorghums have been reported. Records on rainfall and yields at Hassell over a 23-year period indicate that grain sorghums may produce high yields more often than wheat. For climatic zones 3 and 4, it has been found that for the period March 1 through September 30 the effective rainfall will be 6 inches or less in 1 year out of 3; 6 to 10 inches in 1 year out of 3; and 10 inches or more in 1 year out of 3.

The foregoing estimates on yields of wheat and sorghum are based on data collected from nine locations in the period 1947-56. All data collected in climatic zone 4 were from soils that had been summer fallowed, terraced, and farmed on the contour. The yields were similar to those on soils in climatic zone 3 on which no practices for conserving soil and moisture had been used.

Practices that will conserve moisture and prevent soil blowing improve yields in years when there is sufficient moisture to produce a crop. They are explained in the subsection, Management of Cultivated Soils.

### *Yields under irrigation farming*

For the principal irrigated soils, estimated average acre yields of principal crops are given in table 3 for two levels of management.

TABLE 3.—*Estimated average acre yields of crops on the principal irrigated soils under two levels of management*

[Yields in columns A are obtained under ordinary management; yields in columns B are obtained under improved management]

| Soil | Alfalfa | | Grain sorghums | | Wheat | |
|---|---|---|---|---|---|---|
| | A | B | A | B | A | B |
| | *Tons* | *Tons* | *Lb.* | *Lb.* | *Bu.* | *Bu.* |
| Amarillo loam, 0 to 2 percent slopes | 6 | 8 | 4,500 | 7,000 | 30 | 50 |
| Amarillo fine sandy loam, 0 to 2 percent slopes | 6 | 8 | 4,500 | 6,000 | 25 | 45 |
| Arvana loam, shallow, 0 to 2 percent slopes | 4 | 6 | 2,500 | 3,000 | 20 | 20 |
| Church clay loam | 3 | 6 | 2,000 | 4,500 | 25 | 45 |
| Clovis-Amarillo fine sandy loams, 0 to 5 percent slopes | 5 | 7 | 3,500 | 5,000 | 20 | 40 |
| Clovis-Amarillo loams, 0 to 2 percent slopes | 5 | 7 | 3,500 | 5,500 | 25 | 45 |
| Mansker fine sandy loam, 0 to 2 percent slopes | 5 | 6 | 2,000 | 4,000 | 20 | 40 |
| Mansker loam, 0 to 2 percent slopes | 5 | 6 | 2,000 | 4,000 | 20 | 45 |
| Pullman loam, 0 to 2 percent slopes | 5 | 7 | 5,000 | 7,500 | 30 | 55 |
| Pullman-Mansker loams, 0 to 2 percent slopes | 5 | 7 | 3,500 | 7,000 | 25 | 50 |
| Springer fine sandy loam, 0 to 2 percent slopes | 5 | 7 | 3,500 | 5,000 | 25 | 40 |
| Spur soils | 7 | 8 | 5,500 | 7,500 | 35 | 60 |

In columns A are yields expected under ordinary management. This management neglects one or more important practices applied at the higher level of management required to get yields shown in columns B. The yields in columns B are to be expected when all practices required for maximum production of crops have been applied. To obtain the yields in columns B, the farmer does the following:

1. Controls wind and water erosion.
2. Uses a good cropping system that includes the growing of legumes.
3. Seeds adapted varieties of plants at the proper time in a well-prepared seedbed.
4. Uses good irrigation methods to assure uniform and adequate penetration of moisture and to prevent loss of water through deep percolation.
5. Levels fields to the grade suggested for irrigation.
6. Uses nonerosive flows of water in the ditches.
7. Controls insects, diseases, and weeds.

If all of these practices are followed, the yields given in columns B may be expected to continue over a period of years. In the area around House, some farmers apply all of these practices and obtain maximum yields.

## Range Management [2]

The raising of livestock, principally cattle, provides one of the main sources of income in the survey area. This is especially true in years when it is too dry for the growing of grain crops under dryland farming. The livestock are pastured on native range, but they get additional feed from bundled forage and through pasturing winter wheat.

Most of the livestock ranches are in the western part of the survey area. Many small tracts of native grassland lie between cultivated fields in the central and eastern parts.

To get the best yields of range forage, ranchers and farmers need to know about the soils on their holdings, the kinds of plants that grow on them, and the growth habits of these plants.

The kind of vegetation that is native to a given area is determined primarily by the climate; the topography, including slope and exposure; and the kinds of soil. An area that produces essentially the same amount and kind of vegetation, throughout its extent, is called a *range site*. Before settlement began, each range site had a distinct group of plants, commonly known as *climax vegetation*. The kinds of grasses most numerous in the climax vegetation are referred to as *climax dominants*. In this part of New Mexico, the climax vegetation was made up of many kinds of nutritious and palatable perennial grasses. The combination of these grasses was different in the different areas now called range sites.

The climax vegetation is considered the most desirable and productive that a range site will produce under the kind of grazing management now feasible. Under excessive grazing, the vegetation tends to become less desirable, the degree of decline depending on the intensity of grazing. Where livestock have a free choice, they first graze the plants that taste best, "green up" earliest in spring, are most attractive, or are located most conveniently. If grazing is too intensive, the most palatable plants are cropped so closely that they cannot produce seed or store plant nutrients in their roots. During several years of intensive grazing, the palatable plants gradually die out. They are replaced by plants in the native cover that withstand grazing better or are less palatable. This change in the vegetation is termed *plant succession*.

The succession of plants is such that broad groups of plants are recognized on every range site—*decreasers*, *increasers*, and *invaders*. Decreasers are plants in the climax vegetation that are not able to maintain themselves under intensive grazing; they decrease in number or disappear. Increasers are plants in the climax vegetation that tend to increase under intensive grazing because of their habits of growth, method of reproduction, or low palatability. They crowd out the plants called decreasers because they better withstand grazing or may not be grazed. Invaders are weedy plants, not part of the climax vegetation, that establish themselves in a site where the climax vegetation has been weakened or destroyed.

[2] This section was prepared by E. W. WILLIAMS, range conservationist, Soil Conservation Service.

The term *range condition* is used to indicate the quality and quantity of the plant cover on a range site at a given time. The ratings for range condition are *excellent*, *good*, *fair*, and *poor*. Range in excellent condition has a plant cover most nearly like the climax vegetation for the range site; the cover is progressively less like the climax vegetation for the remaining three ratings, good, fair, and poor. Secondarily, ratings for range condition take into account the density of the plant cover, vigor of the better forage plants, amount of litter and plant residues on the soils, and the degree of erosion. The ratings for range condition, therefore, are defined as follows:

- Excellent: Between 75 and 100 percent of the cover consists of climax vegetation; density and vigor of plants and amount of litter are sufficient to prevent active erosion.
- Good: Between 50 and 75 percent of the plant cover consists of climax vegetation; density and vigor of plants and amount of litter are sufficient to keep erosion to a minimum.
- Fair: Between 25 and 50 percent of the plant cover consists of climax vegetation, or the density of perennial plants will permit some erosion.
- Poor: Less than 25 percent of the plant cover consists of climax vegetation, or the density of perennial plants will permit excessive erosion.

Range management should be planned so as to get a plant cover as nearly like the climax vegetation as practicable. The general grazing practices needed are described in the subsection that immediately follows. More detailed information on range management will be found in the subsection, Range Sites.

### *General management of grazing*

To get the highest continuous yields of native forage, the operator needs to control (1) the intensity of grazing, (2) the time of grazing, and (3) the distribution of grazing. These are basic practices on all range sites.

*Proper intensity of grazing.*—This is the practice most needed on rangeland in the survey area. If the number of animals on the range is not adjusted to the carrying capacity, all other range practices are useless. If the operator correctly controls the intensity of grazing, he can keep enough residues on the surface to protect against erosion, and, in rundown areas, improve the quality of the vegetation.

As a guide to proper stocking, note the condition of the *key plants* on a range site. The key plants, normally of two to six species, are those that provide most of the grazing on the site. If they lose vigor, begin to reproduce less, or are replaced by less valuable plants, a change in management is needed. An adjustment in intensity of grazing may be needed, or, as explained in the paragraphs following, a change in kind of livestock or in season of use may be required.

*Deferred grazing.*—This is the practice of moving livestock from one range to another so that areas can be rested, or deferred, from grazing during the growing season. In this way the better plants have an opportunity to build up vigor, mature, and seed. Deferred grazing is one of the best methods of improving range condition.

*Distribution of grazing.*—Livestock tend to overgraze some areas and to undergraze others. Grazing should be distributed evenly over the area. To achieve this, the operator needs to—

1. Distribute watering places so that livestock can reach them easily from all parts of the range.
2. Place fences so they follow the approximate boundaries of the range site or the changes in range condition; then, grazing can be controlled to promote the growth of the better plants. Avoid fencing in pockets of land that cannot be reached readily by livestock.
3. Place salt in areas that are not being grazed enough.

## *Range sites*

In this survey area, eight range sites are recognized. Each site has a different kind of climax vegetation, which has different capacity to withstand intensive grazing.

The kinds and amounts of native plants in the climax vegetation provide a reliable guide to identifying a range site. But after years of intensive grazing, the plant cover may no longer resemble the climax vegetation of the site. In areas where this has happened, the range site can be identified by topography and kinds of soils, because slope and exposure of the soils and the texture of their surface layer are the natural features that most influence the amounts and kinds of vegetation. In this survey area, differences in elevation and in average annual precipitation are not great enough to be used in distinguishing one range site from another.

Following is a discussion of each range site in the survey area. The climax vegetation for each site is described, and suggestions for use and management of the site are given.

### PLAINS UPLAND SITE

This range site is made up of deep and moderately deep loam and silt loam soils that are level to gently sloping. It is the most extensive site in the survey area, and much of the acreage has been cultivated. Most of the larger tracts still in native vegetation are in the western part. Small areas of native vegetation lie between cultivated fields. The soils of this site are:

Alama loam, 0 to 2 percent slopes.
Alama loam, 2 to 5 percent slopes.
Alama silt loam, 0 to 2 percent slopes.
Alama silt loam, 2 to 5 percent slopes.
Amarillo loam, 0 to 2 percent slopes.
Amarillo loam, 2 to 5 percent slopes.
Amarillo loam, valleys, 0 to 2 percent slopes.
Amarillo loam, valleys, 2 to 5 percent slopes.
Arch loam.
Arvana loam, shallow, 0 to 2 percent slopes.
Arvana loam, shallow, 2 to 5 percent slopes.
Clovis-Amarillo loams, 0 to 2 percent slopes.
Clovis-Amarillo loams, 2 to 5 percent slopes.
Clovis-Amarillo loams, valleys, 0 to 2 percent slopes.
Clovis-Amarillo loams, valleys, 2 to 5 percent slopes.
Ima gravelly loam, light-colored variant, 2 to 5 percent slopes.
Ima gravelly loam, light-colored variant, 5 to 10 percent slopes.
Ima loam, 0 to 2 percent slopes.
Ima loam, 2 to 5 percent slopes.
La Lande loam, 0 to 2 percent slopes.
La Lande loam, 2 to 5 percent slopes.
Mansker loam, 0 to 2 percent slopes.
Mansker loam, 2 to 5 percent slopes.
Mansker loam, 5 to 10 percent slopes.
Manwood-Pullman loams.
Portales loam, 0 to 2 percent slopes.
Pullman loam, 0 to 2 percent slopes.
Pullman loam, 2 to 5 percent slopes.
Pullman-Mansker loams, 0 to 2 percent slopes.
Pullman-Mansker loams, 2 to 5 percent slopes.
Tucumcari loam, 0 to 2 percent slopes.
Tucumcari loam, 2 to 5 percent slopes.

The climax vegetation on this site consists of short grasses, principally blue grama (*Bouteloua gracilis*) and buffalograss (*Buchloe dactyloides*); there are small amounts of mid grasses, as side-oats grama (*Bouteloua curtipendula*), little bluestem (*Andropogon scoparius*), galleta (*Hilaria jamesii*), needle-and-thread (*Stipa comata*), silver beardgrass (*Andropogon saccharoides*), vine-mesquite (*Panicum obtusum*), and lesser amounts of western wheatgrass (*Agropyron smithii*) or switchgrass (*Panicum virgatum*). Vine-mesquite, western wheatgrass, and switchgrass are usually confined to small depressions or swales in which water collects.

Mixed with the climax grasses are weed plants. The most common of these are scurfpea (*Psoralea tenuiflora*), scarlet globemallow (*Sphaeralcea coccinea*), plains zinnia (*Zinnia grandiflora*), prairie coneflower (*Ratibida columnaris*), and some species of groundsel (*Senecio* spp.).

Few shrubs are in the climax vegetation. The most common are soapweed (*Yucca glauca*) and tree cactus (*Opuntia arborescens*).

Secondary grasses that make up a very limited part of the climax vegetation are hairy grama (*Bouteloua hirsuta*), sand dropseed (*Sporobolus cryptandrus*), ring muhly (*Muhlenbergia torreyi*), and some species of three-awn grass (*Aristida* spp.).

When the range is in excellent condition, blue grama makes up about three-fourths of the plant population. It grows in large, well-defined clumps and looks like bunchgrass. The presence of palatable mid grasses, such as little bluestem, side-oats grama, and needle-and-thread, indicate the range is in excellent condition.

If the condition of the range declines through intensive use, galleta and buffalograss increase; blue grama becomes thicker, but shorter and more turflike. The vegetative cover is frequently denser than when the site is in excellent condition. This usually is due to the greater proportion of buffalograss in the plant cover and the shorter but more turflike growth of blue grama. The total amount of usable forage, however, is usually less than that on range in excellent condition. Litter and plant residues are often too scarce to provide best protection against erosion.

If the range is in fair condition, the plant cover may consist of almost pure stands of dense, turflike blue grama of medium to low vigor. In other places about half of the cover is made up of patchy stands in which blue grama alternates with buffalograss and galleta; the rest of the vegetation is made up of a mixture of three-awn grasses, ring muhly, sand dropseed, and weeds.

If the range is in poor condition, the site will have one of the following types of plant cover: (1) Blue grama makes up less than one-fourth of the plant cover; the rest consists principally of ring muhly, three-awn grasses, galleta, snakeweed, groundsel, fringed sagebrush,

and similar plants; generally, the blue grama is low in vigor, except where the condition of the site is being improved through better management; (2) blue grama may comprise two-thirds of the thin plant cover, but it occurs in broken, turflike patches or in small, hummocky tufts; the spaces between the clumps of blue grama are covered with snakeweed or annual weeds; the vegetation is usually low in vigor and litter is scarce, and, consequently, wind and water erosion are moderate to severe; (3) abandoned cropland with a cover of weeds or almost pure stands of ring muhly, three-awn grasses, or snakeweed; or (4) barren, or most of the cover is of annual weeds and grasses.

In general, this range site is suitable for grazing in any season and is commonly used the year round. The climax plants provide good grazing in winter, but the site offers little natural protection against storms.

For best yields, the soils on this site need more moisture than the coarser textured, more permeable soils on adjacent sites. Showers of less than half an inch are of little use; most of this moisture evaporates. By controlling grazing, the operator can keep enough plant residues on the surface to increase the water-intake rate, lower the temperature of the soil, and slow down the rate of evaporation.

The soils of this range site are deep to moderately deep; they have enough capacity to retain moisture. Where the topography is favorable, they are well suited to the practice of spreading runoff water.

When this site is in fair or poor condition, operators can make water penetrate better by plowing contour furrows and by pitting and ripping the soil. If, in addition to these practices, grazing is deferred or controlled during the growing season, the condition of the range should improve.

#### SHALLOW UPLAND SITE

This range site occurs throughout the survey area, mostly adjacent to or intermingled with the Plains Upland site. The soils are:

Larimer gravelly loam.
Potter fine sandy loam.
Potter loam.

The Potter soils are medium textured, calcareous, and shallow over caliche. In many places they are stony or gravelly on the surface and throughout the profile. The Larimer soil consists of rounded gravelly material to a depth of 2 feet or more.

The soils of this site are mostly on the side slopes and upper margins of large drainageways and on slopes surrounding the playa lakes. Slopes range from 0 to 15 percent but generally are less than 10 percent.

The climax vegetation is a mixture of mid and short grasses and a few shrubs and palatable forbs. The principal grasses are side-oats grama, little bluestem, New Mexico feathergrass (*Stipa Neomexicana*), blue grama, hairy grama, and, on the southern slopes, black grama (*Bouteloua eriopoda*). Common shrubs are feather peabush (*Dalea formosa*), catclaw mimosa (*Mimosa borealis*), bigelow sagebrush (*Artemisia bigelovi*), soapweed, and squawbush (*Rhus trilobata*). Several shrublike plants are common to this site; they are fringed sagebrush (*Artemisia frigida*), broom snakeweed (*Gutierrezia sarothrae*), stemless pingue (*Hymenoxys acaulis*), and several kinds of wild buckwheat (*Eriogonum* spp.).

If the condition of the range declines because of drought or intensive grazing, New Mexico feathergrass, little bluestem, and needle-and-thread become less abundant or die out. Side-oats grama generally continues to grow, but it lacks vigor and height. The mid grasses are replaced through an increase of blue grama, hairy grama, and such undesirable plants as three-awn grasses, hairy tridens (*Tridens pilosa*), and ring muhly. If the condition of the range declines further, the site frequently has dense stands of broom snakeweed and lesser amounts of stemless pingue, fringed sagebrush, and other shrublike plants.

#### HEAVY BOTTOM-LANDS SITE

This range site is composed of deep, relatively impervious soils that have formed in material derived from redbed shale. It is on slopes of less than 2 percent, mainly adjacent to drainageways or below escarpments. Small areas made up of moderately fine textured soils are around intermittent lakes. Except where deep gullies have formed, the areas of this site are likely to be flooded by runoff from adjacent areas. The soils of this site are:

Church clay loam.
Montoya silty clay loam, 0 to 2 percent slopes.

The climax vegetation on this site is dominated by alkali sacaton (*Sporobolus airoides*), galleta, tobosagrass (*Hilaria mutica*), blue grama, and vine-mesquite. Minor plants are buffalograss, white tridens (*Tridens albescens*), and sacaton (*Sporobolus wrighti*).

Under heavy grazing, alkali sacaton, blue grama, and vine-mesquite tend to be replaced by almost pure stands of tobosagrass. If intensive grazing continues, burrograss (*Scleropogon brevifolius*) often becomes dominant temporarily. Other invaders are ring muhly, creeping muhly (*Muhlenbergia repens*), snakeweed, plains ironweed (*Vernonia marginata*), and many other weeds.

Mesquite is an active invader and frequently becomes the dominant plant. Other shrubs that may occur on this site are chamise (*Atriplex canescens*), common winterfat (*Eurotia lanata*), and rabbitbrush (*Chrysothamnus* spp.).

When under climax vegetation and subject to periodic flooding, this site is highly productive. Yields of 6,000 pounds of air-dry forage per acre can be obtained.

The Montoya soil is susceptible to sheet and gully erosion, especially during long droughts or when the plant cover has been depleted through overuse. A few gullies occur; in other places sheet erosion has removed the surface layer and left the soil devoid of vegetation. These bare areas, often referred to as "slick spots", are extremely difficult to revegetate, either through natural means or by reseeding.

Because of its deep soil and favorable topography, this site will benefit greatly through water spreading. The soils provide very poor material for earthen structures. Dams and diversion structures have frequently failed when installed on this site.

To increase the intake rate of water, you need to maintain vigorous stands of grass and adequate plant residues. For satisfactory yields of forage, control graz-

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ing so that large amounts of litter and residues remain on the surface.

#### BREAKS SITE

This range site is on steep, rocky escarpments that lie between the uplands and the lower lying plains or valleys. In general, the soils are shallow and medium textured, but there are pockets of deep soils. In most places stones or gravel are on the surface and throughout the soil profile. The soils are:

Rough broken and stony land.
Stony rough land, mixed materials.
Stony rough land, Potter materials.

The vegetation of this site is characterized by many species of woody plants. The most common is oneseed juniper (*Juniperus monosperma*). Pinon (*Pinus edulis*) is less prevalent.

Common shrubs are wavyleaf oak (*Quercus undulata*), mountain-mahogany (*Cercocarpus breviflorus*), feather peabush, Apacheplume (*Fallugia paradoxa*), mariola parthenium (*Parthenium incanum*), soapweed, and sacahuista (*Nolina microcarpa*). Shrublike plants common to this site are several kinds of wild buckwheat and fringed sagebrush, broom snakeweed, common winterfat, and rabbitbrush.

Important climax grasses are little bluestem, side-oats grama, black grama, blue grama, hairy grama, New Mexico feathergrass, and Texas timothy (*Lycurus phleoides*). Also, there are small amounts of galleta and several species of three-awn grass. If this site is in a depleted condition, the three-awn grasses are active increasers, and they become the dominant plants.

The amount of forage produced on this site varies, depending on the proportion of woody plants in the plant cover. If the areas are grazed intensively, the woody species, particularly juniper and oak, increase and make up the main part of the plant cover.

The areas of this site are too steep for management practices that require machinery. To conserve the rangeland, control the time and intensity of grazing and locate fences, watering places, and salt so that you get proper distribution of livestock.

#### SANDY PLAINS SITE

The soils of this range site have sandy loam to loamy fine sand surface layers and medium-textured, loamy subsoils. They are deep to moderately deep and nearly level to undulating. The soils take water rapidly and have good water-holding capacity. The following soils are in this range site:

Amarillo fine sandy loam, 0 to 2 percent slopes.
Amarillo fine sandy loam, 2 to 5 percent slopes.
Arch fine sandy loam.
Arch loamy fine sand.
Arvana fine sandy loam, shallow, 0 to 2 percent slopes.
Arvana fine sandy loam, shallow, 2 to 5 percent slopes.
Clovis-Amarillo fine sandy loams, 0 to 5 percent slopes.
Drake fine sandy loam, 2 to 10 percent slopes.
Mansker fine sandy loam, 0 to 2 percent slopes.
Mansker fine sandy loam, 2 to 5 percent slopes.
Mansker fine sandy loam, 5 to 10 percent slopes.
Newkirk sandy loam, 2 to 10 percent slopes.
Portales fine sandy loam, 0 to 2 percent slopes.
San Jose fine sand, moderately deep over sand, 0 to 2 percent slopes.
San Jose fine sand, moderately deep over sand, 2 to 5 percent slopes.
Springer fine sandy loam, 0 to 2 percent slopes.
Springer fine sandy loam, 2 to 5 percent slopes.
Springer fine sandy loam, valleys, 0 to 5 percent slopes.

The vegetation on this site is more complex and contains more species than that on sites made up of finer textured soils. The climax vegetation is dominated by mid grasses. Among the most common are side-oats grama, little bluestem, New Mexico feathergrass, switchgrass, and needle-and-thread. Common short grasses are hairy grama, black grama, and blue grama. Two shrubs that generally occur are soapweed and sand sagebrush (*Artemisia filifolia*). If the range is in climax or excellent condition, buffalograss and galleta are usually lacking or present in only small amounts.

When the climax vegetation begins to decline, hairy grama and blue grama increase and little bluestem, needle-and-thread, New Mexico feathergrass, switchgrass, and other mid grasses tend to decrease. Yucca and sand sagebrush increase, and, except for these shrubs, the plant cover may superficially resemble that of the Plains Upland site.

As the condition of the range declines further, the site may be dominated by soapweed and sand sagebrush mixed with sand dropseed, red lovegrass (*Eragrostis oxylepis*), three-awn grasses, tumble lovegrass (*E. sessilispica*), and sand muhly (*Muhlenbergia arenicola*).

When in poor condition, the site is usually dominated by shrubs, weeds, and grasses of low forage value. The most common perennial plants are soapweed, sand sagebrush, pricklypear cactus (*Opuntia* spp.), and queensdelight (*Stillingia sylvatica*). There are also annual grasses and weeds.

If the range is in excellent or good condition, this site is one of the most productive in the survey area, particularly in years when precipitation is below normal. Because the soils absorb water rapidly, a rainfall of a quarter of an inch may penetrate deep enough to be used for plant growth. Vegetation on this site, therefore, responds better to light and erratic rainfall than that on adjacent sites made up of finer textured soils. Even in years when precipitation is below normal, this site often produces a fair amount of forage. In years of normal precipitation, it may yield more than 2,000 pounds of air-dry forage per acre.

If the range is grazed too closely and does not have enough vegetation, the soil is subject to damage through wind erosion. The mid grasses that make up the climax dominants are damaged quickly if overgrazed. These grasses usually begin to grow earlier in spring than the grasses on the Plains Upland site; at this time they are often grazed closely, even though there is enough mature grass on adjacent sites.

To maintain maximum yields of forage and the best kinds of plants, you need to manage this site carefully and to pay close attention to the growth requirements of the key plants. Provide enough stubble and litter at the end of the growing season to protect the soil against wind erosion.

Contour furrowing, pitting, or other mechanical practices are of little value on the Sandy Plains site. If you place salt away from watering places and, if possible, locate wells on finer textured sites, you can prevent

livestock from concentrating, wearing down the vegetation, and causing soil blowing.

#### DEEP SANDS SITE

This range site is made up of deep, loose loamy fine sands and fine sands. The relief ranges from nearly level to gently sloping, and the ground surface ranges from smooth to dunelike. The following soils are in this site:

Drake loamy fine sand, 2 to 10 percent slopes.
Springer loamy fine sand, 0 to 5 percent slopes.
Tivoli fine sand.

The climax vegetation is dominated by a mixture of tall and mid grasses. Most abundant of the tall climax dominants are sand bluestem (*Andropogon hallii*), little bluestem, yellow Indiangrass (*Sorghastrum nutans*), switchgrass, giant sandreed (*Calamovilfa gigantea*), and giant dropseed (*Sporobolus giganteus*). These plants, along with little bluestem and side-oats grama, make up 70 or more percent of the plant cover. Less than 10 percent of the vegetation consists of blue grama, hairy grama, and other short grasses. In the climax vegetation, there may be small amounts of sand sagebrush, soapweed, sandplum (*Prunus watsonii*), squawbush, and Mormon-tea (*Ephedra trifurca*).

Several species of three-awn, dropseed, and lovegrass may occur in the climax vegetation. These plants become dominant temporarily after the climax vegetation is depleted.

Forbs are fairly abundant on this site; among the more common are scurfpea (*Psoralea tenuiflora*), purple prairieclover (*Petalostemum purpureum*), umbrella plants or wild buckwheat, evening primroses (*Oenothera* spp.), velvetweeds (*Gaura* spp.), bush morningglory (*Ipomoea leptophylla*), and heliotrope (*Heliotropium convolvulaceum*).

As the condition of the range declines, sand sagebrush often becomes the dominant species. When spring rainfall is above normal and the range is in a depleted condition, this site produces many short-lived annual weeds; the most common are species of mustard (*Cruciferae* spp.).

This site is highly productive when covered by climax vegetation. If the climax plants die out, the soil is subject to severe soil blowing. Active sand dunes form on range in poor condition.

Because the soils absorb water rapidly and do not need too much moisture to bring them to field capacity, much of the precipitation can be used for plant growth. As a result, this site yields a high volume of palatable forage. Where the site is in excellent or good range condition, yields of 3,000 to 4,500 pounds of air-dry forage per acre can be expected if there is a normal amount of annual precipitation.

Contour furrowing, pitting, and other mechanical practices are not suitable on this range site. The soils are too sandy for the construction of earth reservoirs or stock ponds, and water for farm use is obtained from wells. If possible, locate the wells adjacent to areas of more stable soils. Lay out salt grounds, feed troughs, corrals or other structures so that livestock do not concentrate in one area. Otherwise, trampling by livestock will cause active sand dunes to form.

Because of the way the tall grasses grow and because the soils are unstable, you need to leave plenty of plant residues and stubble on the surface at the end of the growing season. Bluestems and Indiangrass are easily damaged by close grazing. To protect the soils and keep the plants vigorous, maintain a stubble that averages 8 to 12 inches in height.

#### HEAVY SLOPES SITE

This inextensive range site consists of shallow to deep soils that have slopes of more than 2 percent. The soils have formed from material weathered from shale. The following soils are in this site:

Hassell loam, 2 to 5 percent slopes.
Montoya silty clay loam, 2 to 5 percent slopes.
Regnier silt loam.

The climax vegetation is the same as that on the Heavy Bottom-lands site, but the plant cover is not so dense and the volume of forage is less. This site usually receives some runoff from surrounding areas, but the amount is normally less than that received by the Heavy Bottom-lands site; furthermore, surface drainage is much more rapid.

When the plant cover is depleted, this site is subject to severe sheet erosion. In many places wide, crescent-shaped headcuts are advancing up the slope. There are many gullies, but they are generally not deep to the underlying geologic material.

The soils take water slowly. After the grass cover is depleted or destroyed, part of the surface soil erodes away; then, the soils are more impervious.

This site is difficult to manage. If the cover is depleted, plants recover very slowly. If the soils are denuded, it is almost impossible to get plants to grow again.

#### PLAINS BOTTOM-LANDS SITE

This inextensive range site occurs at intervals on the High Plains. It occupies flat draws and lake terraces. The soils are loam to silt loam in texture, are dark in color, and contain much organic matter. They have formed from alluvium. Because of the low elevation, the soils are subject to periodic overflow. In most places alluvial sediments are being deposited. The soils of this site are:

Lofton clay loam.
Spur soils.

The climax vegetation consists of a mixture of such mid grasses as switchgrass, side-oats grama, little bluestem, western wheatgrass, vine-mesquite, and galleta. In places where deposits of silt are not excessive, blue grama may be plentiful.

In its present condition, this site is usually dominated by a mixture of buffalograss, galleta, and, to some extent, blue grama.

Because the soils are deep and hold much water, this site is well suited to water spreading.

## Engineering Applications[3]

This soil survey report contains information that can be used by engineers to—

(1) Make soil and land use studies that will aid in the selection and development of industrial, business, residential, and recreational sites.
(2) Make estimates of permeability, available moisture capacity, and runoff and erosion characteristics for use in designing drainage structures and planning dams and other structures for the conservation of water and soil.
(3) Make reconnaissance surveys of soil and ground conditions that will aid in selecting highway and airport locations and in planning detailed soil surveys for the intended locations.
(4) Locate sand and gravel for use in structures.
(5) Correlate pavement performance with types of soil and thus develop information that will be useful in designing and maintaining the pavements.
(6) Determine the suitability of soil units for cross-country movements of vehicles and construction equipment.
(7) Supplement information obtained from other published maps and reports and aerial photographs for the purpose of making soil maps and reports that can be used by engineers.

*The mapping and the descriptive report are somewhat generalized, however, and should be used only in planning more detailed field surveys to determine the in-place condition of the soil at the site of proposed dams, bridges, primary highways, or irrigation systems.*

### Test Data and Estimated Engineering Properties

Samples of the Pullman loams, the most extensive soils in the survey area, were analyzed by the Bureau of Public Roads (table 4). The results of these analyses, along with other guides, were used in estimating the engineering properties of the soils and their suitability for various kinds of engineering (tables 5 and 6).

### Classification Systems and Definition of Terms

Engineers commonly use two classification systems that express, by means of symbols, the relative suitability of soil materials for use in structures. As shown in table 4, the classifications take into account size of soil separates (mechanical analyses); liquid limit; and plasticity index. The classification systems, as well as several engineering terms that may be unfamiliar, are explained as follows:

*AASHO system.*[4]—Most highway engineers classify soil materials in accordance with the system approved by the American Association of State Highway Officials. In

[3] This section was prepared by CHARLES SOLGA, engineering specialist, and C. H. DIEBOLD, soil specialist, Soil Conservation Service. The authors wish to express their appreciation of the help given them by C. W. JOHNSON, materials and research engineer, and B. E. RUTZ, research engineer, of the New Mexico State Highway Department.

[4] AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS. STANDARD SPECIFICATIONS FOR HIGHWAY MATERIALS AND METHODS OF SAMPLING AND TESTING. pt. 1, ed. 7, 1955.

TABLE 4.—*Engineering test data [1] for soil*

| Soil name and location | Parent material | Bureau of Public Roads report number | Depth | Horizon | Moisture-density: Maximum dry density | Moisture-density: Optimum moisture content |
|---|---|---|---|---|---|---|
| | | | *Inches* | | *Lbs. per cu. ft.* | *Percent* |
| Pullman loam: 300 feet E. and 600 feet S. of NW corner sec. 6, T. 6 N., R. 32 E. (modal profile). | Fine-textured sediments. | S 31913 | 4–8 | $A_3$ | 116 | 13 |
| | | S 31914 | 15–25 | $B_{21}$ | 105 | 18 |
| | | S 31915 | 33–40 | $B_{2ca}$ | 110 | 16 |
| | | S 31916 | 56–84 | $C_{ca1}$ | 116 | 14 |
| Pullman-Mansker loams: 125 feet S. and 150 feet W. of NE corner sec. 35, T. 5 N., R. 29 E. | Fine-textured sediments. | S 31917 | 4–9 | $A_3$–$B_1$ | 116 | 13 |
| | | S 31918 | 9–19 | $B_{21}$ | 101 | 22 |
| | | S 31919 | 33–56 | $C_{ca1}$ | 108 | 17 |
| Pullman loam (approaches Amarillo): 1,100 feet S. and 50 feet E. of NW corner sec. 36, T. 6 N., R. 28 E. (parent material sandier than that in modal profile). | Fine-textured sediments. | S 31920 | 2½–8 | A–$B_1$ | 118 | 12 |
| | | S 31921 | 8–21 | $B_{21}$ | 110 | 15 |
| | | S 31922 | 33–55 | $B_{3ca}$–$C_{ca1}$ | 118 | 13 |

[1] Tests performed by Bureau of Public Roads in accordance with standard procedures of the American Association of State Highway Officials (AASHO).

[2] Mechanical analyses according to the AASHO Designation: T–88: Results by this procedure frequently may differ somewhat from results that would have been obtained by the soil-survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil-survey procedure, the fine material is analyzed by the pipette method and the material coarser than

this system soil materials are classified in seven principal groups. The groups range from A-1, consisting of gravelly soils of high bearing capacity, to A-7, consisting of clay soils having low strength when wet. (See tables 5 and 6.) Within each group the relative engineering value of the soil material is indicated by a group index number. Group indexes range from 0 for the best materials to 20 for the poorest. The classifications used in this report are based on analyses of Pullman soils made by the Bureau of Public Roads (table 4), and on characterization studies and classifications of soil texture made by the Soil Conservation Service.

*Unified system.*[5]—In this system soil materials are identified as coarse grained (8 classes), fine grained (6 classes), or highly organic (1 class). The symbols expressing these various classes are shown in tables 5 and 6. The classifications are based on analyses of Pullman soils made by the Bureau of Public Roads (table 4) and on characterization studies and classifications of soil texture made by the Soil Conservation Service.

*Available water.*—The amount of moisture in the soil that can be taken up by plants in amounts significant to their growth. For a given soil it represents the range between field capacity, the maximum amount of water the soil can hold, and the level at which plants with mature root systems begin to wilt. In table 6, available moisture is noted in terms of inches of water needed to wet dry soil material to a depth of 1 foot.

*Dispersion.*—Stability of soil particles less than 0.005 millimeter in diameter. A soil with low dispersion is stable, and its aggregates do not slake readily. A soil with high dispersion is unstable when water is applied.

*Liquid limit.*—The moisture content at which the soil material passes from a plastic to a liquid state.

*Moisture density.*—If a soil material is compacted at successively higher moisture contents, assuming that the compactive effort remains constant, the density of the compacted material will increase until the optimum moisture content is reached. After that, the density decreases with increase in moisture content. The highest dry density obtained in the compaction test is termed maximum dry density. Data showing moisture density are important in earthwork, for, as a rule, optimum stability is obtained if the soil is compacted to about the maximum dry density when it is at approximately the optimum moisture content.

*Plastic limit.*—The moisture content at which the soil material passes from a solid to a plastic state.

*Plasticity index.*—The numerical difference between the liquid limit and plastic limit. The plasticity index indicates the range of moisture content within which a soil material is plastic.

*Percolation rate.*—Ratings are based on measurements made by C. H. Diebold on some of the soils in the area and on other soils in eastern New Mexico. Measurements were made on saturated cores taken by the method described by Uhland,[6] using a variable head of 1 inch of water.

*Shrink-swell potential.*—This refers to how much the soil expands or contracts when it becomes either

[5] WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS, U. S. ARMY. THE UNIFIED CLASSIFICATION SYSTEM. Tech. Memo. 3-357, 3 v. 1953.

[6] UHLAND, R. E., and O'NEAL, A. M. SOIL PERMEABILITY DETERMINATIONS FOR USE IN SOIL AND WATER CONSERVATION. SCS-TP-101, 36 pp., illus. 1951.

*samples taken from 3 soil profiles*

| Mechanical analysis [2] | | | | | | | | | | Liquid limit | Plasticity index | Classification | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Percentage passing sieve— | | | | | | Percentage smaller than— | | | | | | AASHO [3] | Unified [4] |
| 3/8-in. | No. 4 (4.7 mm.) | No. 10 (2.0 mm.) | No. 40 (0.42 mm.) | No. 60 (0.25 mm.) | No. 200 (0.074 mm.) | 0.05 mm. | 0.02 mm. | 0.005 mm. | 0.002 mm. | | | | |
| | | | 100 | 99 | 76 | 64 | 39 | 26 | 21 | 23 | 7 | A-4(8) | ML-CL. |
| | | | 100 | 99 | 82 | 72 | 52 | 41 | 37 | 35 | 18 | A-6(11) | CL. |
| | | 100 | 99 | 97 | 79 | 68 | 48 | 37 | 33 | 31 | 15 | A-6(10) | CL. |
| | | 100 | 99 | 98 | 81 | 73 | 62 | 52 | 38 | 25 | 11 | A-6(8) | CL. |
| | | 100 | 98 | 95 | 67 | 58 | 39 | 29 | 23 | 24 | 10 | A-4(6) | CL. |
| | | 100 | 99 | 96 | 77 | 71 | 56 | 46 | 42 | 44 | 23 | A-7-6(14) | CL. |
| | | 100 | 93 | 89 | 68 | 63 | 56 | 50 | 38 | 28 | 10 | A-4(7) | CL. |
| | | 100 | 99 | 95 | 65 | 51 | 32 | 24 | 19 | 21 | 7 | A-4(6) | ML-CL. |
| | | 100 | 99 | 96 | 68 | 59 | 41 | 34 | 31 | 31 | 15 | A-6(9) | CL. |
| 100 | 99 | 98 | 95 | 90 | 55 | 45 | 33 | 28 | 24 | 26 | 11 | A-6(4) | CL. |

2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes of soils.

[3] Based on Standard Specifications for Highway Materials and Methods of Sampling and Testing (Pt. 1): The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes, AASHO Designation: M 145-49.

[4] Based on the Unified Soil Classification System, Tech. Memo. No. 3-357, v. 1. Waterways Expt. Sta., March 1953.

TABLE 5.—*Estimated physical properties*

| Symbol on map | Soil | Description | Depth | Classification: USDA texture [1] | Classification: Unified | Classification: AASHO |
|---|---|---|---|---|---|---|
| | | | *Inches* | | | |
| Aa | Alama loam, 0 to 2 percent slopes. | 3 to 5 feet or more of well-drained sandy silt or clayey silt derived from valley fill; many areas of the Alama silt loams are in broad swales. | 0 to 4 | Loam | ML | A–4 |
| Ab | Alama loam, 2 to 5 percent slopes. | | 4 to 26 | Clay loam | CL | A–6 |
| Ac | Alama silt loam, 0 to 2 percent slopes. | | 26 to 52 | Loam | ML | A–4 |
| Ad | Alama silt loam, 2 to 5 percent slopes. | | | | | |
| Ae | Amarillo fine sandy loam, 0 to 2 percent slopes. | 3 to 5 feet of well-drained clayey sand to sandy clay; formed in reworked, mixed Tertiary deposits on the High Plains; soft caliche at depths of 3 to 5 feet. | 0 to 7 | Loam | SM–ML | A–4 |
| Af | Amarillo fine sandy loam, 2 to 5 percent slopes. | | 7 to 40 | Sandy clay loam | CL | A–4 to A 6 |
| Ag | Amarillo loam, 0 to 2 percent slopes. | | 40 to 60+ | Sandy clay loam | SM–ML | A–4 |
| Ah | Amarillo loam, 2 to 5 percent slopes. | | | | | |
| Ak | Amarillo loam, valleys, 0 to 2 percent slopes. | | | | | |
| Am | Amarillo loam, valleys, 2 to 5 percent slopes. | | | | | |
| An | Arch fine sandy loam (0 to 2 percent slopes). | Gray lacustrine materials in playas. | 0 to 30 | Loam | SMu | A–2 to A–4 |
| Ao | Arch loam (0 to 2 percent slopes). | | | | | |
| Ap | Arch loamy fine sand (0 to 2 percent slopes). | | | | | |
| Ar | Arvana fine sandy loam, shallow, 0 to 2 percent slopes. | 10 to 20 inches of reddish-brown, mixed clayey sands underlain by hard caliche. | 0 to 6 | Loam | SC–ML | A–4 |
| As | Arvana fine sandy loam, shallow, 2 to 5 percent slopes. | | 6 to 14 | Sandy clay loam | SC | A–4 |
| At | Arvana loam, shallow, 0 to 2 percent slopes. | | | | | |
| Au | Arvana loam, shallow, 2 to 5 percent slopes. | | | | | |
| Ca | Church clay loam. | 3 to 5 feet or more of fat clays on first terraces above large, intermittent lakes. | 0 to 18 | Clay | CH | A–7 |
| | | | 18 to 48 | Clay | CH | A–7 |
| Cb | Clovis-Amarillo fine sandy loams, 0 to 5 percent slopes. | 2 to 3 feet of well-drained clayey sand underlain by soft caliche. | 0 to 6 | Fine sandy loam | SM | A–2 |
| | | | 6 to 24 | Sandy clay loam | SC–CL | A–4 to A–6 |
| | | | 24 to 60 | Loam | SM–ML | A–4 |
| Cc | Clovis-Amarillo loams, 0 to 2 percent slopes. | 2 to 3 feet of well-drained clayey sand to sandy clay derived from mixed, reworked Tertiary deposits; soft, marllike caliche at depths of 2 or 3 feet. | 0 to 9 | Loam | SM–ML | A–4 |
| Cd | Clovis-Amarillo loams, 2 to 5 percent slopes. | | 9 to 30 | Sandy clay loam | CL | A–4 |
| Ce | Clovis-Amarillo loams, valleys, 0 to 2 percent slopes. | | 30 to 60+ | Sandy clay loam | SM–ML | A–4 |
| Cf | Clovis-Amarillo loams, valleys, 2 to 5 percent slopes. | | | | | |
| Da | Drake fine sandy loam, 2 to 10 percent slopes. | 3 to 5 feet or more of silty sands deposited by the wind as low hills on the leeward side of depressions. | 0 to 30 | Fine sandy loam | SM | A–4 |

See footnotes at end of table.

*and brief description of the soils*

| Percentage passing sieve— | | | Percolation rate | Structure | Available moisture | Reaction | Dispersion | Shrink-swell potential [2] |
|---|---|---|---|---|---|---|---|---|
| No. 200 (0.074 mm.) | No. 10 (2.0 mm.) | No. 4 (4.7 mm.) | | | | | | |
| | | | *Inches per hour* | | *Inches per foot of depth* | pH [3] | | |
| 55–65 | 100 | 100 | 0. 5 –1. 5 | Moderate, coarse, granular | 2. 0 | 8. 0 | Low | Low. |
| 75–85 | 100 | 100 | . 05–0. 5 | Subangular blocky | 2. 0 | 8. 0 | Low | Moderate. |
| 55–65 | 100 | 100 | . 5 –1. 5 | Subangular blocky | 2. 0 | 8. 0 | Low | Low. |
| | | | | | | | | |
| 45–60 | 100 | 100 | . 5 –1. 5 | Subangular blocky | 2. 0 | 6. 0–7. 0 | Low | Low. |
| 50–65 | 100 | 100 | . 5 –1. 5 | Prismatic breaking to subangular blocky. | 2. 0 | 7. 0–7. 5 | Low to moderate. | Moderately low to low. |
| 40–60 | 85 | 90 | 1. 0 –3. 0 | Massive | 1. 0 –2. 0 | 7. 8–8. 5 | Low to moderate. | Low. |
| | | | | | | | | |
| 30–45 | 99 | 100 | 1. 0 –2. 0 | Subangular blocky | 2. 0 | 8. 0–8. 5 | High | Low. |
| | | | | | | | | |
| 45–60 | 100 | 100 | . 5 –1. 5 | Subangular blocky | 2. 0 | 6. 0–7. 0 | Low | Low. |
| 45–50 | 100 | 100 | 5 –1. 5 | Prismatic, breaking to subangular blocky. | 2. 0 | 7. 0–7. 5 | Low | Moderate to low. |
| | | | | | | | | |
| 80–90 | 100 | 100 | . 05–0. 20 | Weak subangular blocky | 2. 0 | 8. 0–8. 5 | Low | Moderate. |
| 80–90 | 100 | 100 | 0–0. 05 | Weak subangular blocky | 2. 0 | 8. 0–8. 5 | Low | Moderate. |
| | | | | | | | | |
| 25–40 | 100 | 100 | 2. 5 –4. 0 | Single grain | 1. 2 | 7. 0–7. 5 | Low | Low. |
| 40–55 | 100 | 100 | . 5 –1. 5 | Subangular blocky | 2. 0 | 7. 5–8. 0 | Low | Low. |
| 40–60 | 85 | 90 | . 5 –2. 5 | Massive | 2. 0 | 8. 0–8. 5 | Moderate | Low. |
| | | | | | | | | |
| 45–60 | 100 | 100 | . 5 –1. 5 | Subangular blocky | 2. 0 | 7. 0–7. 5 | Low | Low. |
| 55–70 | 100 | 100 | . 5 –1. 5 | Subangular blocky | 2. 0 | 7. 0–7. 5 | Low | Low. |
| 40–60 | 100 | 100 | 1. 0 –3. 0 | Massive | 1. 0 –2. 0 | 7. 8–8. 5 | Moderate | Low. |
| | | | | | | | | |
| 35–50 | 100 | 100 | 2. 0 | Single grain to massive | 2. 0 | 7. 8–8. 5 | Moderate | Low. |

TABLE 5.—*Estimated physical properties*

| Symbol on map | Soil | Description | Depth | Classification | | |
|---|---|---|---|---|---|---|
| | | | | USDA texture [1] | Unified | AASHO |
| | | | *Inches* | | | |
| Db | Drake loamy fine sand, 2 to 10 percent slopes. | 3 to 5 feet of poorly graded sands deposited by the wind as low hills on the leeward side of small depressions. | 0 to 60 | Loamy fine sand | SP–SM | A–2 |
| Ha | Hassell loam, 2 to 5 percent slopes. | 2 to 3 feet of clayey sand overlying highly plastic clay; underlain by red shale; occurs on gently sloping valley floors. | 0 to 7 | Clay loam | CL–CH | A–7 |
| | | | 7 to 31 | Clay | CH | A–7 |
| Ia | Ima gravelly loam, light-colored variant, 2 to 5 percent slopes. | 3 to 5 feet of gravelly silt-sand mixture; smear of Tertiary gravel; occurs on gently rolling topography. | 0 to 9 | Gravelly loam | GM | A–2; A–4 |
| Ib | Ima gravelly loam, light-colored variant, 5 to 10 percent slopes. | | 9 to 42 | Loam | SM | A–4 |
| Ic | Ima loam, 0 to 2 percent slopes. | 3 to 5 feet of silty sand and sand-silt mixture derived from valley fill; gently rolling topography. | 0 to 7 | Loam | SM | A–4 |
| Id | Ima loam, 2 to 5 percent slopes. | | 7 to 60 | Loam | SM | A–4 |
| La | La Lande loam, 0 to 2 percent slopes. | 3 to 5 feet or more of well-drained sand-silt mixture derived from valley fill; gently sloping topography. | 0 to 60 | Loam | SM | A–4 |
| Lb | La Lande loam, 2 to 5 percent slopes. | | | | | |
| Lc | Larimer gravelly loam | 3 to 5 feet or more of poorly graded gravel-sand to sand-silt mixture formed from Tertiary outwash; rolling topography. | 0 to 8 | Gravelly loam | GM | A–2; A–4 |
| | | | 8 to 60 | Very gravelly loam | GM | A–1 |
| Ld | Lofton clay loam | 3 to 5 feet or more of lean clay and inorganic silt derived from lacustrine materials. | 0 to 4 | Clay loam | CL | A–6 |
| | | | 4 to 16 | Silty clay loam | CL | A–6 |
| | | | 16 to 24 | Silty clay loam | ML | A–4 |
| | | | 24 to 60 | Fine sandy loam | ML | A–4 |
| Ma | Mansker fine sandy loam, 0 to 2 percent slopes. | 1½ to 2½ feet of calcareous, silty sand underlain by soft caliche; formed from reworked Tertiary outwash on sloping parts of High Plains. | 0 to 15 | Loam | ML | A–4 |
| | | | 15 to 26 | Loam | CL–ML | A–4 |
| Mb | Mansker fine sandy loam, 2 to 5 percent slopes. | | | | | |
| Mc | Mansker fine sandy loam, 5 to 10 percent slopes. | | | | | |
| Md | Mansker loam, 0 to 2 percent slopes. | | | | | |
| Me | Mansker loam, 2 to 5 percent slopes. | | | | | |
| Mf | Mansker loam, 5 to 10 percent slopes. | | | | | |
| Mg | Manwood-Pullman loams. | A soil complex consisting mainly of the Pullman soils; scabby Manwood soils, underlain by hard caliche, cover less than 5 percent of this mapping unit. | 0 to 3 | Loam | ML | A–4 |
| | | | 3 to 10 | Clay | CH | A–7 |
| | | | 10 to 20 | Clay | CH | A–7 |
| Mh | Montoya silty clay loam, 0 to 2 percent slopes. | 3 to 5 feet or more of fat clay on the bottom lands; formed from redbed materials; no water table. | 0 to 8 | Silty clay loam | CL | A–4 to A–6 |
| | | | 8 to 54 | Silty clay loam | CH | A–7 |
| Mk | Montoya silty clay loam, 2 to 5 percent slopes. | | | | | |

See footnotes at end of table.

*and brief description of the soils*—Continued

| Percentage passing sieve— No. 200 (0.074 mm.) | No. 10 (2.0 mm.) | No. 4 (4.7 mm.) | Percolation rate | Structure | Available moisture | Reaction | Dispersion | Shrink-swell potential [2] |
|---|---|---|---|---|---|---|---|---|
| | | | *Inches per hour* | | *Inches per foot of depth* | *pH* [3] | | |
| 5–25 | 100 | 100 | 5.0–7.0 | Single grain | 1.0 | 7.5–8.5 | Moderate | Low. |
| 60–70 | 100 | 100 | .05–0.5 | Subangular blocky | 2.0 | 7.5–8.5 | Moderate | Moderate. |
| 80–90 | 100 | 100 | .0–0.5 | Angular blocky | 2.0 | 7.5–8.5 | Low | High. |
| 35–45 | 65–80 | 65–80 | 1.0–2.0 | Granular | 1.25 | 7.5–8.5 | Low | Low. |
| 40–50 | 75–85 | 80–90 | .5–1.5 | Subangular blocky | 2.0 | 7.5–8.5 | Low | Low. |
| 40–50 | 90 | 90 | .5–1.5 | Granular | 2.0 | 7.5–8.5 | Low | Low. |
| 40–50 | 85 | 90 | .5–1.5 | Massive | 2.0 | 7.5–8.5 | Low | Low. |
| 40–50 | 100 | 100 | .5–1.5 | Subangular blocky | 2.0 | 7.5–8.0 | Low | Low. |
| 35–45 | 65–75 | 65–75 | 2.5–3.5 | Subangular blocky | 1.2 | 7.5–8.0 | Low | Low. |
| 15–25 | 20–40 | 30–40 | 4.0–5.0 | Single grain | 1.0 | 8.0–8.5 | Low | Low. |
| 55–65 | 100 | 100 | .05–0.5 | Platy | 2.0 | 7.0–7.5 | Low | Moderate. |
| 60–80 | 100 | 100 | .05–0.5 | Subangular blocky | 2.0 | 7.0–7.5 | Low | Moderate. |
| 60–80 | 100 | 100 | .05–0.5 | Subangular blocky | 2.0 | 7.5–8.0 | Low | Low. |
| 50–60 | 100 | 100 | .5–2.5 | Massive | 2.0 | 8.0–8.5 | Low | Low. |
| 70–80 | 100 | 100 | 1.5 –2.5 | Subangular blocky | 2.0 | 7.5–8.0 | High | Low to moderate. |
| 60–80 | 100 | 100 | 2.5 –4.0 | Massive | | 8.0–8.5 | High | Low to moderate. |
| 50–60 | 100 | 100 | .5 –1.5 | Platy | 2.0 | 6.5 | High | Low. |
| 70–80 | 100 | 100 | 0 –0.05 | Columnar | 2.0 | 7.6 | Moderate | High. |
| 70–80 | 100 | 100 | .05 –0.25 | Angular blocky | 2.0 | 7.7 | Moderate | Moderate. |
| 70 | 100 | 100 | .05 –0.5 | Platy | 2.0 | 8.0–8.5 | Low | Moderate. |
| 80 | 100 | 100 | .0 –0.05 | Angular blocky | 2.0 | 8.0–8.5 | Low | High. |

TABLE 5.—*Estimated physical properties*

| Symbol on map | Soil | Description | Depth | Classification: USDA texture [1] | Unified | AASHO |
|---|---|---|---|---|---|---|
| | | | *Inches* | | | |
| Na | Newkirk sandy loam, 2 to 10 percent slopes. | 10 to 20 inches of sand-silt to clay-sand mixture over sandstone; gently rolling topography. | 0 to 6 | Heavy sandy loam | SM | A-2; A-4 |
| | | | 6 to 17 | Sandy clay loam | SC | A-4 |
| Pa | Portales fine sandy loam, 0 to 2 percent slopes. | 2 feet of silty sand underlain by strongly calcareous very fine sand. | 0 to 6 | Fine sandy loam | ML | A-4 |
| | | | 6 to 22 | Loam | ML | A-4 |
| | | | 22 to 60 | Sandy loam | SM-ML | A-4 |
| Pb | Portales loam, 0 to 2 percent slopes. | 2 feet of inorganic silt and very fine sand underlain by strongly calcareous very fine sand and silty sand. | 0 to 24 | Loam | ML | A-4 |
| | | | 24 to 60 | Sandy loam | SM-ML | A-4 |
| Pc | Potter fine sandy loam | 6 to 12 inches of sand-silt underlain by hard caliche; nearly level to rolling topography. | 0 to 9 | Fine sandy loam | SM | A-2 |
| Pd | Potter loam | 6 to 12 inches of silty sand underlain by hard caliche; nearly level to rolling topography. | 0 to 9 | Loam | SM | A-4 |
| Pe | Pullman loam, 0 to 2 percent slopes. | 3 to 5 feet or more of lean clay underlain by soft caliche; gently sloping topography of the High Plains. | 0 to 6 | Loam | ML | A-4 |
| Pf | Pullman loam, 2 to 5 percent slopes. | | 6 to 40 | Clay loam | CL | A-6 |
| | | | 40 to 54 | Clay loam | CL | A-6 |
| | | | 54+ | Loam | CL | A-6 |
| Pg | Pullman-Mansker loams, 0 to 2 percent slopes. | 2 to 3 feet of lean clay underlain by soft caliche; gently sloping topography of the High Plains. | 0 to 7 | Loam | ML | A-4 |
| | | | 7 to 20 | Clay loam | CL | A-6 or A-7 |
| | | | 20 to 26 | Clay loam | CL | A-6 |
| Ph | Pullman-Mansker loams, 2 to 5 percent slopes. | | 26 to 64 | Loam | CL-ML | A-6 or A-4 |
| Ra | Regnier silt loam | 6 to 12 inches of silt and clay-silt underlain by shale; gently rolling parts of valley slopes. | 0 to 6 | Silt loam | ML | A-4 |
| | | | 6 to 12 | Silty clay loam | CL | A-6 |
| Rc | Rough broken and stony land. | 10 to 20 inches of stony sand-silt mixture and stony clay underlain by shale and sandstone; on escarpments at edge of the High Plains. | 0 to 6 | Stony loam | GM | A-1 |
| | | | 6 to 15 | Stony clay loam | GC | A-6 |
| Sa | San Jose fine sand, moderately deep over sand, 0 to 2 percent slopes. | 3 to 5 feet of poorly graded sand and silt-sand mixture on the bottom lands. | 0 to 6 | Fine sand | SW-SM | A-3 |
| | | | 6 to 20 | Loam | ML | A-4 |
| | | | 20 to 66 | Loamy fine sand | SM | A-2 |
| Sb | San Jose fine sand, moderately deep over sand, 2 to 5 percent slopes. | | | | | |
| Sc | Springer fine sandy loam, 0 to 2 percent slopes. | 3 to 5 feet or more of sand-silt mixture underlain by soft caliche; on gentle slopes of the High Plains. | 0 to 8 | Fine sandy loam | SM | A-2 |
| | | | 8 to 28 | Fine sandy loam | SM | A-2 |
| Sd | Springer fine sandy loam, 2 to 5 percent slopes. | | 28 to 45 | Fine sandy loam | SM | A-2 |
| | | | 45 to 80 | Sandy clay loam | CL-ML | A-4 |
| Se | Springer fine sandy loam, valleys, 0 to 5 percent slopes. | | | | | |
| Sf | Springer loamy fine sand, 0 to 5 percent slopes. | 3 to 5 feet or more of well-graded sand to sand-silt mixture underlain by soft caliche. | 0 to 8 | Loamy fine sand | SW-SM | A-2 or A-3 |
| | | | 8 to 28 | Fine sandy loam | SM | A-2 |
| | | | 28 to 45 | Loamy fine sand | SW-SM | A-2 |
| | | | 45 to 80 | Fine sandy loam | SM | A-4 |

See footnotes at end of table.

*and brief description of the soils*—Continued

| Percentage passing sieve— | | | Percolation rate | Structure | Available moisture | Reaction | Dispersion | Shrink-swell potential [2] |
|---|---|---|---|---|---|---|---|---|
| No. 200 (0.074 mm.) | No. 10 (2.0 mm.) | No. 4 (4.7 mm.) | | | | | | |
| | | | *Inches per hour* | | *Inches per foot of depth* | *pH* [3] | | |
| 30–40 | 90 | 95 | 1. 5 –2. 5 | Granular | 1. 5 –2. 0 | 7. 5–8. 0 | Low | Low. |
| 40–50 | 90 | 95 | . 5 –1. 5 | Subangular blocky | 2. 0 | 7. 5–8. 0 | Low | Low. |
| 45–55 | 100 | 100 | . 5 –2. 5 | Platy | 2. 0 | 7. 0–7. 5 | Low | Low. |
| 50–60 | 100 | 100 | . 5 –1. 5 | Subangular blocky | 2. 0 | 7. 5–8. 0 | Low | Low. |
| 40–55 | 100 | 100 | 1. 5 –2. 5 | Massive | 2. 0 | 7. 5–8. 0 | Low | Low. |
| 50–60 | 100 | 100 | . 5–1. 5 | Subangular blocky | 2. 0 | 7. 5–8. 0 | Low | Low. |
| 40–55 | 100 | 100 | 1. 5–2. 5 | Massive | 2. 0 | 7. 5–8. 0 | Low | Low. |
| 20–30 | 75 | 85 | 2. 5–4. 0 | Single grain | 1. 2 | 7. 5–8. 0 | Low | Low. |
| 35–50 | 60–80 | 70–90 | . 5–2. 5 | Granular | 1. 5–2. 0 | 7. 5–8. 0 | Low | Low. |
| 60–70 | 100 | 100 | . 5–1. 5 | Granular | 2. 0 | 6. 5–7. 0 | Low | Low. |
| 65–85 | 100 | 100 | . 05–0. 25 | Angular blocky | 2. 0 | 7. 0–7. 5 | Low | Moderate. |
| 55–75 | 100 | 100 | . 05–0. 50 | Subangular blocky | 2. 0 | 7. 5–8. 0 | Low | Moderate. |
| 70–85 | 100 | 100 | . 5–2. 5 | Massive | 2. 0 | 7. 5–8. 0 | Low | Low. |
| 60–70 | 100 | 100 | . 5–1. 5 | Granular | 2. 0 | 6. 5–7. 0 | Low | Low. |
| 70–80 | 100 | 100 | . 05–0. 25 | Angular blocky | 2. 0 | 7. 0–7. 5 | Low | Moderate. |
| 70–80 | 100 | 100 | . 05–0. 5 | Angular blocky | 2. 0 | 7. 5–8. 0 | Low | Moderate. |
| 65–85 | 100 | 100 | . 5–2. 05 | Massive | 2. 0 | 7. 5–8. 0 | Low | Low. |
| 60–70 | 90 | 95 | . 05–0. 5 | Granular | 2. 0 | 7. 5–8. 0 | Moderate | Low to moderate. |
| 70–80 | 85 | 90 | . 05–0. 5 | Subangular blocky | 2. 0 | 7. 5–8. 0 | Low | Moderate. |
| 20 | 35 | 40 | . 5 –1. 5 | Granular | . 7 –1. 0 | 7. 5–8. 0 | Low | Low. |
| 40–50 | 60 | 70 | . 05–0. 5 | Angular blocky | 1. 0 –1. 2 | 7. 5–8. 0 | Low | Moderate. |
| 10 | 100 | 100 | 5. 0 –7. 0 | Single grain | 0. 7 | 7. 5–8. 0 | Low | Low. |
| 50–60 | 100 | 100 | . 5 –1. 5 | Subangular blocky | 2. 0 | 7. 5–8. 0 | Low | Low. |
| 20 | 100 | 100 | 2. 5 –5. 0 | Single grain | 1. 0 | 7. 5–8. 0 | Low | Low. |
| 20–30 | 100 | 100 | 2. 5 –5. 0 | Granular | 1. 0 –1. 2 | 7. 0–7. 5 | Low | Low. |
| 25–35 | 100 | 100 | 1. 5 –2. 5 | Subangular blocky | 1. 5 | 7. 0–7. 5 | Low | Low. |
| 15–30 | 100 | 100 | 2. 5 –5. 0 | Subangular blocky | 1. 2 | 7. 5–8. 0 | Low | Low. |
| 60–70 | 100 | 100 | . 5 –2. 5 | Massive | 1. 5 –2. 0 | 8. 0–8. 5 | Low | Low. |
| 10–20 | 100 | 100 | 5. 0 –7. 0 | Single grain | 1. 0 | 7. 0–7. 5 | Low | Low. |
| 15–25 | 100 | 100 | 1. 5 –2. 5 | Subangular blocky | 1. 2 | 7. 0–7. 5 | Low | Low. |
| 10–20 | 100 | 100 | 5. 0 –7. 0 | Single grain | 1. 0 | 7. 5–8. 0 | Low | Low. |
| 40–50 | 100 | 100 | 1. 5 –2. 5 | Massive | 1. 2 | 7. 5–8. 0 | Low | Low. |

TABLE 5.—*Estimated physical properties*

| Symbol on map | Soil | Description | Depth | Classification | | |
|---|---|---|---|---|---|---|
| | | | | USDA texture [1] | Unified | AASHO |
| | | | *Inches* | | | |
| Sg | Spur soils (0 to 5 percent slopes). | 3 to 5 feet or more of dark-colored clayey silt to lean clay. | 0 to 4 | Silt loam | ML | A–4 |
| | | | 4 to 42 | Clay loam | CL | A–6 |
| | | | 42 to 60 | Silt loam | ML | A–4 |
| Sh | Stony rough land, mixed materials. | Up to 1 foot of silty gravel underlain by limestone, sandstone, and shale; occurs on escarpments. | 0 to 6 | Stony loam | GM | A–1 to A–2 |
| Sk | Stony rough land, Potter materials. | Up to 1 foot of gravel-and-silt mixture underlain by caliche; occurs on escarpments. | 0 to 6 | Stony loam | GM | A–1 to A–2 |
| Ta | Tivoli fine sand (2 to 10 percent slopes). | 3 to 5 feet or more of deep sand; occurs in sandhills. | 0 to 60 | Fine sand | SW–SMd | A–3 |
| Tb | Tucumcari loam, 0 to 2 percent slopes. | 2½ to 3 feet of lean clay and inorganic silt underlain by soft caliche; occurs on gentle slopes on valley fill. | 0 to 4 | Loam | ML | A–4 |
| | | | 4 to 14 | Clay loam | CL | A–6 |
| Tc | Tucumcari loam, 2 to 5 percent slopes. | | 14 to 30 | Clay loam | CL | A–6 |
| | | | 30 to 60 | Loam | ML | A–4 or A–6 |

[1] United States Department of Agriculture classification of soil texture.

[2] Some of the ratings are based on undisturbed cores.

TABLE 6.—*Engineering*

| Soil series and symbols for mapping units [1] | Suitability of soil material for— | | Suitability as source of— | | Soil ratings and features affecting suitability for— | |
|---|---|---|---|---|---|---|
| | Road subgrade | Road-fill and subbase | Topsoil | Sand and gravel | Dikes or diversions and terraces | Stock tanks and reservoir areas |
| Alama (Aa, Ab, Ac, Ad) | Poor to fair | Fair; easily eroded on slopes. | Fair, but surface soil highly erodible. | Unsuitable | Good to fair; susceptible to piping; easily eroded; difficult to compact. | Good; seepage losses low; below a depth of 2 feet, a more permeable layer may be exposed. |
| Amarillo (Ae, Af, Ak, Am, Ag, Ah) | Fair to good | Good | Good, except for soft caliche. | Unsuitable | Good; fairly stable; impervious when compacted. | Good; moderately permeable but can be compacted to seal. |
| Arch (An, Ao, Ap) | Fair | Poor to fair | Poor; soil is highly erodible and deficient in minor elements. | Unsuitable | Fair; erodible; difficult to compact. | Fair; permeable; difficult to compact. |
| Arvana (Ar, As, At, Au) | Poor to fair | Poor to unsuitable. | Good | Unsuitable | Good; fairly stable. | Good; fairly impervious if compacted but otherwise permeable. |

See footnotes at end of table.

*and brief description of the soils*—Continued

| Percentage passing sieve— No. 200 (0.074 mm.) | No. 10 (2.0 mm.) | No. 4 (4.7 mm.) | Percolation rate | Structure | Available moisture | Reaction | Dispersion | Shrink-swell potential [2] |
|---|---|---|---|---|---|---|---|---|
| | | | *Inches per hour* | | *Inches per foot of depth* | *pH* [3] | | |
| 50-70 | 100 | 100 | 0.5 -1.5 | Subangular blocky | 2.0 | 6.5-7.0 | Low | Low. |
| 65-75 | 100 | 100 | .25-0.5 | Subangular blocky | 2.0 | 7.0-7.5 | Low | Low. |
| 50-70 | 100 | 100 | .5 -1.5 | Massive | 2.0 | 7.5-8.0 | Low | Low. |
| 20-30 | 50 | 60 | .5 -1.5 | Granular | 1.0 | 7.5-8.0 | Low | Low. |
| 20-30 | 50 | 70 | .5 -1.5 | Granular | 1.0 | 7.5-8.0 | Low | Low. |
| 2-15 | 100 | 100 | 7.0 -10.0 | Single grain | .7 | 6.5-7.0 | Low | Low. |
| 50-60 | 100 | 100 | .5 -1.5 | Platy | 2.0 | 7.5-8.0 | Low | Low. |
| 60-70 | 100 | 100 | .05-0.5 | Subangular blocky | 2.0 | 7.5-8.0 | Low | Low. |
| 60-70 | 100 | 100 | .05-0.5 | Subangular blocky | 2.0 | 7.5-8.0 | Low | Low. |
| 50-06 | 85 | 90 | .5 -2.5 | Massive | 2.0 | 8.0-8.5 | Moderate | Low. |

[3] A pH of more than 7.0 indicates the soil is alkaline; a pH of less than 7.0 indicates the soil is acid.

*interpretation of the soils*

| Soil ratings and features affecting suitability for—Continued | | | | | |
|---|---|---|---|---|---|
| Embankments of irrigation reservoirs | Waterways | Irrigation | Irrigation ditches | Water spreading | Range pitting and chiseling |
| Good to fair; difficult to compact. | Moderately erodible. | (2) | (2) | Gentle slopes; deep; good available moisture capacity; slow permeability; highly erodible. | Good; stone free; good available moisture capacity; smooth topography. |
| Good; adequate strength and stability and impervious when compacted. | Moderately erodible. | Loams: High available moisture capacity; medium intake rate of water. | Loams: Moderate loss of water in ditches. | Loams: Broad gentle slopes in valleys; deep; good available moisture capacity; moderate permeability; erodible. | Loams: Good; stone free; good available moisture capacity; smooth topography. |
| | | Fine sandy loams: Medium available moisture capacity; high intake rate of water; easily overirrigated. | Fine sandy loams: High loss of water in ditches. | Fine sandy loams: Medium available moisture capacity; high intake rate of water; easily eroded. | Fine sandy loams: Poor; same as for the loams, but high intake rate of water; susceptible to soil blowing. |
| Good; unstable; difficult to compact. | Highly erodible | (2) | (2) | Permeable in surface layer; highly erodible. | Unsuitable; surface soil erodible. |
| Good; impervious with compaction; fairly stable. | Moderately erodible. | Loams: Low available moisture capacity; medium intake rate of water. | Loams: Moderate loss of water in ditches. | Low available moisture capacity. | Poor; low available moisture capacity; smooth topography; loams can be pitted, but fine sandy loams not suitable for pitting because of soil blowing. |

See footnotes at end of table.

TABLE 6.—*Engineering interpretation*

| Soil series and symbols for mapping units [1] | Suitability of soil material for— | | Suitability as source of— | | Soil ratings and features affecting suitability for— | |
|---|---|---|---|---|---|---|
| | Road subgrade | Road-fill and subbase | Topsoil | Sand and gravel | Dikes or diversions and terraces | Stock tanks and reservoir areas |
| Church (Ca) | Poor to fair | Unsuitable | Unsuitable | Unsuitable | Fair; impervious; resistant to erosion and piping when compacted. | Good; impermeable. |
| Clovis-Amarillo fine sandy loams (Cb). | Poor to fair | Poor to fair | Suitable | Unsuitable | Good to fair; fairly stable; not subject to piping; impermeable when compacted. | Fair; permeable without compaction. |
| Clovis-Amarillo loams (Cc, Cd, Ce, Cf). | Poor to fair | Poor to fair | Suitable | Unsuitable | Good to fair; fairly stable; not subject to piping; impermeable when compacted. | Fair; permeable without compaction. |
| Drake (Da, Db) | Fair | Fair | Poor | Unsuitable | Fair, but site unsuitable. | Poor; high permeability without compaction. |
| Hassell (Ha) | Poor to fair | Unsuitable | Poor | Unsuitable | Fair; resistant to erosion and piping when compacted. | Good; impervious. |
| Ima gravelly loams (Ia, Ib). | Fair to good | Good to fair | Poor | Poor | Good; fairly stable. | Fair; moderate permeability without compaction. |
| Ima loams (Ic, Id) | Fair to good | Fair to good | Good | Unsuitable | Good; fairly stable. | Fair; moderate permeability without compaction. |
| La Lande (La, Lb) | Good | Fair to good | Unsuitable | Poor | Good; resistant to erosion and piping; easy to compact. | Poor; high permeability without compaction. |
| Larimer (Lc) | Fair to good | Good to fair | Poor | Poor | Excellent to good; fairly stable. | Good to fair; moderate permeability without compaction. |
| Lofton (Ld) | Poor to fair | Unsuitable | Fair | Unsuitable | Fair; not subject to erosion and piping with compaction. | Good; low permeability. |
| Mansker (Ma, Mb, Mc, Md, Me, Mf) | Poor to fair | Unsuitable | Poor | Unsuitable | Fair; erodible; stable with compaction; not subject to piping or erosion. | Poor to fair; high permeability. |

See footnotes at end of table.

*of the soils*—Continued

| Soil ratings and features affecting suitability for—Continued | | | | | |
|---|---|---|---|---|---|
| Embankments of irrigation reservoirs | Waterways | Irrigation | Irrigation ditches | Water spreading | Range pitting and chiseling |
| Fair; difficult to compact. | Moderately erodible but generally has good cover of grass. | Moderate available moisture capacity; low intake rate of water. | Low loss of water in ditches. | Gentle slopes; low intake rate of water; moderate available moisture capacity. | Good; low intake rate of water; moderate available moisture capacity. |
| Good to fair; fairly stable and is impervious with compaction. | Moderately erodible. | Low available moisture capacity; high intake rate of water; easily overirrigated. | High loss of water in ditches; ditchbanks unstable. | Erodible (soil blowing); high intake rate of water. | Poor; subject to soil blowing. |
| Good to fair; fairly stable; impervious with compaction. | Moderately erodible. | Moderate available moisture capacity; intake of water 1 inch per hour, on the average; easily irrigated. | Moderate loss of water in ditches. | Moderately erodible; moderate intake rate of water. | Good; stone free; moderate available moisture capacity; smooth topography. |
| Fair, but unsuitable because it is semipervious with compaction; fairly stable. | Unsuitable | Unsuitable | Unsuitable | Unsuitable; rolling; erodible; high intake rate of water. | Unsuitable; high intake rate of water; soil blowing. |
| Fair; impervious | Highly erodible | (2) | (2) | Gentle slopes; low intake rate of water; moderate available moisture capacity. | Good; low intake rate of water and moderate available moisture capacity. |
| Good; fairly stable; good compaction with proper moisture control. | Slightly erodible | (2) | (2) | Unsuitable; rolling topography. | Unsuitable; gravelly. |
| Good; stable to fairly stable; practically impervious with compaction. | Moderately erodible. | (2) | (2) | Moderate intake rate of water; high available moisture capacity. | Good; moderately high available moisture capacity and intake rate of water. |
| Good; reasonably stable; not particularly suitable for shells. | Slightly erodible | (2) | (2) | Moderate intake rate of water; high available moisture capacity. | Good; moderately high available moisture capacity and intake rate of water. |
| Excellent to good; fairly stable; good compaction with proper moisture control. | Slightly erodible | (2) | (2) | Unsuitable; rolling topography. | Unsuitable; gravelly. |
| Fair; may be used for embankments with proper moisture control; poor stability; top 16 inches used for impervious cores. | Moderately erodible. | (2) | (2) | Low intake rate of water; high available moisture capacity. | Good; low intake rate of water and high available moisture capacity. |
| Fair; fair stability; proper moisture control needed for compaction. | Moderately erodible. | Low to moderate available moisture capacity; high intake rate of water. | High loss of water in ditches; erodible; ditchbanks give way. | Erodible; high intake rate of water; low to moderate available moisture capacity. | Unsuitable; high intake rate of water, low available moisture capacity, and soil blowing. |

See footnotes at end of table.

TABLE 6.—*Engineering interpretation*

| Soil series and symbols for mapping units [1] | Suitability of soil material for— | | Suitability as source of— | | Soil ratings and features affecting suitability for— | |
|---|---|---|---|---|---|---|
| | Road subgrade | Road-fill and subbase | Topsoil | Sand and gravel | Dikes or diversions and terraces | Stock tanks and reservoir areas |
| Manwood-Pullman (Mg) | Poor to fair | Unsuitable | Unsuitable | Unsuitable | Fair; when compacted, soil resists erosion and piping and is fairly stable. | Good; practically impervious. |
| Montoya (Mh, Mk) | Poor to fair | Unsuitable | Unsuitable | Unsuitable | Fair; when compacted, soil resists erosion and piping and is fairly stable. | Good; practically impervious. |
| Newkirk (Na) | Poor to good (soil only 10 or 12 inches thick in many places). | Poor to good | Good | Unsuitable | Good; when compacted, soil is fairly stable and resists erosion. | Fair; moderately permeable. |
| Portales (Pa, Pb) | Poor to fair | Fair to unsuitable. | Fair | Unsuitable | Fair to good; erodible; poor to fairly stable when compacted. | Fair; moderately permeable with compaction. |
| Potter (Pc, Pd) | Fair to good (soil only 6 to 12 inches thick). | Poor to good | Poor | Unsuitable | Good, but soils shallow; fairly stable, and resistant to erosion when compacted. | Unsuitable; permeable. |
| Pullman (Pe, Pf) | Poor to fair | Unsuitable | Fair | Unsuitable | Good; stable, impervious, and resistant to erosion when compacted. | Good; practically impervious. |
| Pullman-Mansker (Pg, Ph). | Poor to fair | Unsuitable | Fair | Unsuitable | Good to fair; stable, impervious, and resistant to erosion when compacted. | Good; practically impervious. |
| Regnier (Ra) | Poor to fair | Unsuitable | Poor | Unsuitable | Good to fair; stable, impervious, and resistant to erosion when compacted. | Good; practically impervious. |
| Rough broken and stony land (Rc). | Good to excellent. | Fair to good | Unsuitable | Unsuitable | Fair; but general topography unsuitable. | Good; practically impermeable. |
| San Jose (Sa, Sb) | Fair | Poor to fair | Poor | Poor | Good to fair; erodible; fairly stable when compacted; compaction qualities good; unsuitable for shells. | Poor; moderately to rapidly permeable. |

See footnotes at end of table.

*of the soils*—Continued

| Soil ratings and features affecting suitability for—Continued | | | | | |
|---|---|---|---|---|---|
| Embankments of irrigation reservoirs | Waterways | Irrigation | Irrigation ditches | Water spreading | Range pitting and chiseling |
| Fair; fair to poor compaction characteristics; when compacted, soil is fairly stable and practically impervious. | Manwood soils are highly erodible. | (2) | (2) | Gentle slopes; low intake rate of water; moderate available moisture capacity. | Fair, but poor in Manwood spots; low intake rate of water and moderate available moisture capacity. |
| Fair; when compacted, soil is impervious and fairly stable. | Highly erodible | (2) | (2) | Erodible; low intake rate of water; high available moisture capacity. | Poor; subject to overflow; low intake rate of water and high available moisture capacity. |
| Good; when compacted, soil is fairly stable and impervious; not suited for shells but used in cores. | Moderately erodible. | (2) | (2) | Moderate to high intake rate of water; low available moisture capacity. | Poor; moderate to high intake rate of water and low available moisture capacity. |
| Fair to good; when compacted, poor to fairly stable; compaction characteristics good; proper moisture control essential. | Moderately erodible. | (2) | (2) | Erodible; moderate intake rate of water; moderate available moisture capacity. | Good, moderate intake rate of water and moderate available moisture capacity. |
| Good; but soil is too shallow to be suitable. | Slightly erodible; underlain by hard caliche at depths of 6 to 12 inches. | (2) | (2) | Shallow | Unsuitable; shallow. |
| Good; stable; use in impervious cores and blankets; fair to good compaction characteristics. | Moderately erodible. | High available moisture capacity; low intake rate of water. | Low loss of water in ditches; ditchbanks stable. | Uniform topography; low intake rate of water; high available moisture capacity. | Good; low intake rate of water and high available moisture capacity. |
| Good to fair; avoid Mansker; use Pullman material for embankment. | Moderate erosion on sloping areas. | Moderate available moisture capacity; low intake rate of water. | Low loss of water from ditches; ditchbanks stable. | Uniform topography; low intake rate of water; moderate available moisture capacity. | Good; low intake rate of water and moderate available moisture capacity. |
| Good to fair, but soil too shallow to be suitable. | Highly erodible; underlain by soft shale at depths of 6 to 12 inches. | (2) | (2) | Low available moisture capacity. | Unsuitable; low available moisture capacity. |
| Fair; in places topography is suitable. | Unsuitable | (2) | (2) | Unsuitable | Unsuitable. |
| Good to fair; compaction good with proper moisture control; fairly stable, but not suited to shells. | Highly erodible | (2) | (2) | Erodible; high intake rate of water; low available moisture capacity. | Poor; high intake rate of water, moderate available moisture capacity, and erodible. |

See footnotes at end of table.

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TABLE 6.—*Engineering interpretation*

| Soil series and symbols for mapping units [1] | Suitability of soil material for— | | Suitability as source of— | | Soil ratings and features affecting suitability for— | |
|---|---|---|---|---|---|---|
| | Road subgrade | Road-fill and subbase | Topsoil | Sand and gravel | Dikes or diversions and terraces | Stock tanks and reservoir areas |
| Springer (Sc, Sd, Se, Sf). | Fair to good | Fair to good but not suitable below depths of 4 feet. | Poor | Unsuitable | Good; fairly stable when compacted; good compaction characteristics. | Poor; moderately to rapidly permeable. |
| Spur (Sg) | Poor to fair | Unsuitable | Excellent | Unsuitable | Fair to good; stable; fair to good compaction characteristics. | Good; slow permeability. |
| Stony rough land (Sh, Sk). | Good | Fair to depths of 6 inches. | Unsuitable | Unsuitable | Unsuitable | Unsuitable |
| Tivoli (Ta) | Good | Fair to good | Unsuitable because of wind erosion. | Poor | Fair; good when compacted; fairly stable; slopes need protection from erosion. | Poor; high permeability. |
| Tucumcari (Tb, Tc) | Poor to fair | Fair; easily eroded on slopes. | Fair; but surface soil is highly erodible. | Unsuitable | Good, but susceptible to piping; easily eroded; difficult to compact. | Good; seepage losses low; below a depth of 2 feet a more permeable layer may be exposed. |

[1] No interpretations are given for Riverwash because the soil material is too variable to rate.

wet or dry. Some of the ratings for shrink-swell potential in table 5 are based on undisturbed cores.

## Infiltrometer Studies

The results of infiltrometer studies made by C. H. Diebold and W. A. Buchanan from 1950 through 1952 are shown in table 7.

An infiltrometer with an F-type nozzle was used to provide simulated rainfall on plots of different soils 5 feet 1 inch by 6 feet in size. A storm of the intensity expected to occur once in 10 years was simulated. All of the runoff water from each plot was collected and measured every 6 minutes. The amount of soil loss was measured by taking 1-quart sediment samples between each runoff reading. The water intake was calculated after the amount of runoff had been determined.

On the next day water was again applied to the same plots. This is referred to as a wet run. For the wet runs, water intake was lower and soil losses were higher. Tillage pans were found to be prevalent.

The limited infiltrometer data indicate that after Pullman loam was chiseled to a depth of 12 inches with centers 5 feet apart you could expect to reduce runoff during intensive storms by about one-fourth. This applies to fields used for both wheat and grain sorghums. One year after the deep chiseling on Pullman loam, the amount of runoff increased, but it was less than the runoff in areas that had not been chiseled. Whether or not deep chiseling pays depends in part on the frequency of storms that produce a large amount of runoff.

# *Formation and Classification of Soils*

Five main factors interact in the process of soil formation. They are (1) kind of parent materials, (2) climate under which the soil material has accumulated and existed since accumulation, (3) plant and animal life on and in the soil, (4) relief, or lay of the land, and (5) the length of time the forces of soil development have acted on the soil material.[7]

## Factors of Soil Formation

The part that each of the five factors played in the formation of the soils of the Southwest Quay Area is explained in the following discussion.

### *Parent materials*

The soils of this survey area have formed on several kinds of parent materials, including Tertiary outwash, old alluvium, recent alluvium, windblown sands, and residuum weathered from shale, sandstone, and caliche.

[7] UNITED STATES DEPARTMENT OF AGRICULTURE. SOILS AND MEN. U. S. Dept. of Agr. Yearbook. 1232 pp., illus. 1938.

*of the soils*—Continued

| Soil ratings and features affecting suitability for—Continued | | | | | |
|---|---|---|---|---|---|
| Embankments of irrigation reservoirs | Waterways | Irrigation | Irrigation ditches | Water spreading | Range pitting and chiseling |
| Good; good compaction characteristics with proper control of moisture. | Highly erodible | Low available moisture capacity; high intake rate of water. | High loss of water in ditches. | Erodible; high intake rate of water; low available moisture capacity. | Poor; high intake rate of water, low available moisture capacity, and erodible. |
| Fair to good; fair stability; good compaction; practically impervious. | Low position | High available moisture capacity; moderate intake rate of water. | Low loss of water in ditches. | Moderate intake rate of water; high available moisture capacity. | Poor; subject to flooding; moderate intake rate of water and high available moisture capacity. |
| Unsuitable | Unsuitable | (2) | (2) | Unsuitable | Unsuitable. |
| Fair; good compaction; fairly stable but slopes need protection from erosion; impervious. | Erodible | (2) | (2) | Unfavorable topography. | Unsuitable; soil blowing. |
| Good, but difficult to compact. | Moderately erodible. | (2) | (2) | Gentle slopes; deep; good available moisture capacity; slowly permeable; highly erodible. | Stone free; good available moisture capacity; smooth topography. |

[2] Not enough water available for irrigation.

Except for two small areas in the western part, all of this survey area is on the High Plains. These plains consist of material derived from the Ogallala formation of Tertiary age (fig. 10). The material was laid down as outwash during the Rocky Mountain uplift. As the mountains rose, the sea that covered the area was pushed back. The Rockies were bare of vegetation, and erosion was very severe. Sediments were washed many miles and formed the High Plains. These sediments were later reworked and sorted by the wind. Calcium carbonate was leached downward and formed a layer of caliche.

The extreme western part of the area differs from the rest because erosion removed the Ogallala formation. This probably occurred during the glacial period, when there probably was considerably more rainfall than at present. Along the breaks between the High Plains and the lower areas in the western part of the survey area, the deposit of caliche is exposed as caprock. Below the caprock, sandstone and shale of Jurassic age are exposed, and some material from the Ogallala formation has been reworked and deposited. Consequently, the pattern of soils in the western part of the survey area is varied and little resembles that on the High Plains.

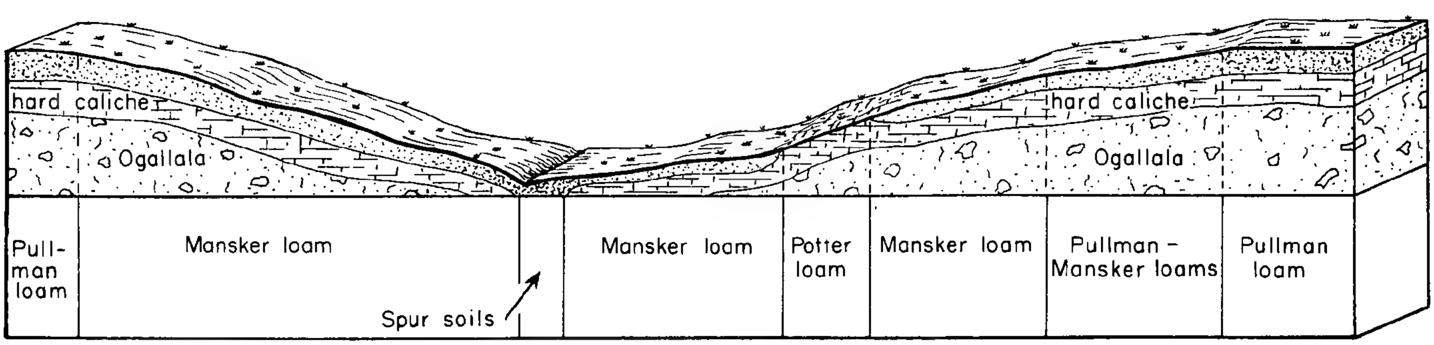



***Figure 10.*—Typical pattern of soils and parent material at Blanco Creek on the High Plains. Pullman soils are on gentle slopes at the top of the divide, and Mansker soils are in rolling areas leading to the stream channel.**

TABLE 7.—*Effects of simulated rainfall on soils cultivated in different ways*

[Figures shown in columns A are measurements obtained after the initial application of water; those in columns B are measurements obtained after water was applied to the same plots on the next day; the simulated rainfall was applied for 1 hour to the Amarillo soil and the Pullman soil cultivated with a duckfoot attachment and for 0.7 hour to the Clovis and other Pullman soils; all the soils had slopes of 1 percent]

| Soil type and treatment | Runoff | | Average intake of water | | Soil loss | |
|---|---|---|---|---|---|---|
| | A | B | A | B | A | B |
| | *Percent* | *Percent* | *Inches* | *Inches* | *Tons per acre* | *Tons per acre* |
| Amarillo loam: | | | | | | |
| One-way diskplow, 3 inches deep | 35 | 60 | 1. 27 | 0. 84 | 0. 6 | 1. 2 |
| Duckfoot, 3 inches deep | 20 | 62 | 1. 69 | . 81 | . 9 | 1. 4 |
| Clovis fine sandy loam: | | | | | | |
| 14-inch blade, 3 inches deep, and chisel, 5 inches deep and 12 inches apart | 12 | 62 | 2. 08 | . 92 | . 6 | 3. 4 |
| 14-inch blade, 3 inches deep, and chisel, 10 inches deep, with centers 5 feet apart | 1 | 51 | 2. 12 | 1. 14 | . 2 | ---------- |
| Pullman loam: | | | | | | |
| Duckfoot, 3 inches deep | 20 | 62 | 1. 67 | . 57 | . 5 | 1. 1 |
| Sweep, 3 inches deep, and chisel, 12 inches deep, with centers 5 feet apart | 10 | 30 | 1. 97 | 1. 51 | . 2 | ---------- |
| A year later on the field just described—one-way 3 inches deep | 20 | 54 | 1. 88 | 1. 04 | ---------- | ---------- |
| 30-inch sweep blade, 3 inches deep, and chisel 12 inches deep, with centers 6 feet apart | 28 | 60 | 1. 66 | 1. 01 | . 7 | 1. 0 |
| 30-inch sweep blade | 45 | 67 | 1. 37 | . 78 | ---------- | ---------- |

### *Relief*

In the survey area, differences in degree of slope, especially above the caprock, are slight; therefore, relief has had little effect on soil formation. On the High Plains most of the landscape consists of long, gentle swells with a slope of less than 2 percent. But in areas next to playa lakes and along major drainageways, the slopes are steeper, or have a gradient of 5 to 10 percent. Typical soils in these places are the Potter and Mansker, which are shallow and not well developed. Here, soil is being eroded away almost as fast as it forms, and less moisture enters the soil profile. As a result, the process of soil formation is slow. In contrast, the Amarillo and Pullman soils are deep and nearly level; they retain more moisture and are developing faster.

Along the western part of the survey area, the terrain below the caprock is steep and rolling. Soil-forming processes have varied greatly in adjacent areas. Soils that show little or no profile development lie next to deep, well-developed soils. For example, the deep, well-developed Amarillo loams, valleys, are adjacent to Ima gravelly loam, light-colored variant, which shows little profile development.

### *Climate*

The climate—precipitation, temperature, humidity, and wind—significantly affects soil development. In the survey area, the annual rainfall averages between 15 and 19 inches. Summers are long and warm; winters are mild but there are short cold spells. The temperature is ideal for vigorous plant and animal activity, but the fairly low supply of moisture limits the influence of plants and animals on soil formation.

Under the amount of precipitation that now falls in the area, it is doubtful that soils such as the Pullman could have become so deep and well developed. During the period 1947-56, for example, soils in the survey area were seldom moist to a depth of 36 inches. Examination of a Pullman soil, however, will show that clayey material has been leached downward in the profile to depths of 50 to 60 inches. The amount of moisture necessary to carry clay this far down must have come when rainfall was greater.

Strong winds have influenced the formation of the soils. Most soils in the survey area show some evidence of wind action. The Tivoli soil in the southwestern corner of the survey area provides a good example of the effect of recent wind action. The soil has dunelike relief, indicating this wind action. The Drake soils, on the leeward side of playas on the High Plains, have formed in windblown material, but the sediments were deposited earlier than those of the Tivoli soil. The Drake soils are moundlike, or ridged, and are of uniform texture to a depth of several feet.

### *Plant and animal life*

The plant and animal life on and in the soil strongly influences the formation of a soil. The type and amount of vegetation are important. These are determined in part by the climate and in part by the kind of soil material. In soil formation, more is known about the influence of vegetation than that of micro-organisms and larger forms of animal life. In the survey area the native vegetation consisted mainly of mid and short grasses.

Vegetation adds organic matter to the soil; this influences the structure and physical condition of the soil. The varying amounts of organic matter that have accumulated in the soils depend upon the factors influencing the kind and amount of vegetation. The largest amount of organic matter occurs where conditions are best for plant growth. Vegetation influences the climatic conditions within the soils by providing shade that helps check evaporation and increases the available moisture capacity.

Soil micro-organisms attack raw plant residues and decompose them into a form of nutrients available to plants. The micro-organisms strongly affect the chemistry of the soil, which, in turn, influences soil formation.

### *Time*

The length of time required for a soil to reach a state of equilibrium with its environment depends upon the combined action of the soil-forming factors and the intensity of the action. In this area, soils develop in a dry climate under sparse vegetation. The action of climate and vegetation is slow, and a long time is required before a soil reaches maturity, or equilibrium with its environment.

The soils of the area differ in degree of development because their parent materials were exposed to soil-forming processes at different times. The soils below the caprock in the western part of the survey area are much younger than those on the High Plains above the caprock. The soils in the western part could not start to develop until the caprock and underlying material had been eroded and deposited on the sides and floors of the valleys. This process of erosion began after the soils on the High Plains had begun to develop.

Except for the Alama, Amarillo loam, valleys, and Tucumcari soils, all the soils below the caprock show less profile development than the Pullman, Manwood, Amarillo, and similar soils of the High Plains.

## *Classification of Soils by Great Soil Groups*

The lower groupings of soil classification—phases, types, and series—are explained in the introduction to the Descriptions of Soils and in the Glossary. Briefly, a soil type consists of one or more phases, and a soil series, of one or more soil types. Soil types or phases are the units shown on the detailed soil map in the back part of the report.

Soil series are classified into a broader category, the great soil groups. Each great soil group is made up of soils that have certain internal characteristics in common.

This survey is in an area transitional between the Reddish Chestnut soil zone and the Reddish Brown soil zone. Table 8 lists the soil series of the survey area by great soil groups and summarizes some factors that have affected development of the soils.

TABLE 8.—*Great soil groups and important characteristics of the soils*

| Great soil group and soil series | Physiographic position | Relief | Parent material | Native vegetation |
|---|---|---|---|---|
| Reddish Chestnut: | | | | |
| Amarillo | High Plains and high benches below the caprock. | Nearly level to gently undulating. | Tertiary outwash | Short and mid grasses. |
| Arvana | High Plains | Nearly level to gently rolling. | Tertiary outwash | Short and mid grasses. |
| Clovis | High Plains and high benches below the caprock. | Nearly level to gently rolling. | Tertiary outwash | Short and mid grasses. |
| Hassell | Slopes and ridges above the valley floor. | Sloping to gently rolling | Redbed sediments of the Jurassic and Triassic ages. | Short and mid grasses. |
| La Lande | Slopes and floors of valleys. | Nearly level to gently rolling. | Old valley fill of the Triassic, Jurassic, and Tertiary ages. | Short and mid grasses. |
| Lofton | Depressions | Nearly flat; smooth slopes. | Tertiary outwash | Short and mid grasses. |
| Newkirk | Slopes and tops of knolls and ridges. | Undulating to hilly | Mainly from material weathered from sandstone. | Short and mid grasses. |
| Pullman | High Plains | Nearly level to gently rolling. | Tertiary outwash | Short and mid grasses. |
| Reddish Brown: | | | | |
| Alama | Slopes and plains below the caprock. | Nearly level to gently sloping. | Old valley fill of the Triassic, Jurassic, and Tertiary ages. | Short and mid grasses. |
| Springer | High Plains and high benches below the caprock | Nearly level to gently rolling. | Tertiary outwash and and sandy sediments deposited by wind. | Short and mid grasses. |
| Tucumcari | Low terraces below the caprock. | Level to gently sloping | Old valley fill of the Triassic, Jurassic, and Tertiary ages. | Short and mid grasses. |

TABLE 8.—*Great soil groups and important characteristics of the soils*—Continued

| Great soil group and soil series | Physiographic position | Relief | Parent material | Native vegetation |
|---|---|---|---|---|
| Calcisol: | | | | |
| Arch | Broad, slight depressions | Nearly level; smooth slopes. | Calcareous alluvium | Short and mid grasses. |
| Church | Depressions | Nearly level; smooth slopes. | Sediments deposited by water. | Short and mid grasses. |
| Mansker | Slopes of draws and playas. | Nearly level to sloping | Tertiary outwash | Short and mid grasses. |
| Portales | Broad, slight depressions | Nearly level; smooth slopes. | Sediments deposited by water. | Short and mid grasses. |
| Solonetz: | | | | |
| Manwood | High Plains | Nearly level to gently rolling. | Tertiary outwash | Short and mid grasses. |
| Brown: | | | | |
| Larimer | Slopes of draws in Cunevoy Basin. | Strongly rolling to rough and broken. | Tertiary outwash | Short and mid grasses. |
| Alluvial: | | | | |
| Ima | Alluvial slopes below the caprock and edges of terraces. | Gently sloping to strongly rolling. | Alluvium derived from Tertiary material. | Short and mid grasses. |
| Montoya | Bottom lands and depressions. | Nearly level to gently sloping. | Calcareous alluvium | Short and mid grasses. |
| San Jose | Recent alluvial fans | Nearly level to gently rolling. | Recent alluvium derived from Tertiary outwash. | Tall and mid grasses. |
| Spur | Adjacent to drainageways on low terraces. | Nearly level | Calcareous alluvium | Short and mid grasses. |
| Regosol: | | | | |
| Drake | Windblown sands | Undulating to hilly | Calcareous windblown sediments. | Mid and tall grasses. |
| Tivoli | Stabilized sand dunes | Rolling to hilly | Windblown sands | Tall and mid grasses. |
| Lithosol: | | | | |
| Potter | Slopes of draws | Rolling to hilly | Caliche | Short and mid grasses. |
| Regnier | Knobs and ridges rising above the valley floor. | Sloping to gently rolling | Redbeds of the Jurassic and Triassic age. | Short and mid grasses. |

*Reddish Chestnut soils.*—Soils of the Amarillo, Arvana, Clovis, and Pullman series are typical of the Reddish Chestnut great soil group. These soils are characterized by (1) a surface soil that contains more than 1 percent organic matter and has a color value of less than 5.5 when dry and 3.5 when moist (Munsell color notations), (2) a textural B horizon, and (3) enriched zones of secondary calcium carbonate. Other Reddish Chestnut soils in the survey area are the Hassell, La Lande, Newkirk, and Lofton.

*Reddish Brown soils.*—Soils of the Alama, Springer, and Tucumcari series belong to the Reddish Brown great soil group. These soils are below the caprock in the dry climatic zone 5. They are similar to Reddish Chestnut soils except that their surface soils may be lighter colored and contain less organic matter.

*Calcisols.*—Soils of the Arch, Church, Mansker, and Portales series belong to the Calcisol great soil group. These soils occur in association with Reddish Chestnut soils, but they lack a textural B horizon. They have an enriched zone of secondary calcium carbonate within 2 feet of the surface.

*Solonetz soils.*—In this survey area only the Manwood series belongs to the Solonetz great soil group. The Manwood soil has been leached of an appreciable amount of exchangeable sodium. This soil, which occurs in association with Reddish Chestnut soils, has a $B_2$ horizon with columnar structure.

*Brown soils.*—Only the Larimer series belongs to the Brown great soil group. This weakly developed soil has formed from gravelly outwash. The very thin, brown surface layer is underlain by lighter colored material.

*Alluvial soils.*—The soils of the San Jose, Ima, Montoya, and Spur series are classified as Alluvial soils. They show little or no profile development. The thin, sandy surface layer overlies stratified sands and clays.

*Regosols.*—Soils of the Drake, Ima, Montoya, Spur, and Tivoli series belong to the Regosol great soil group. These deep soils have little or no profile development. The Tivoli soil is 95 percent sand.

*Lithosols.*—The Potter and Regnier series are Lithosols. Like the Regosols, these soils show little or no development of a profile. They were formed from material weathered from sedimentary rocks, including caliche. Bedrock generally is within 18 inches of the surface.

## *Laboratory Studies*

Table 9 shows the results of the chemical and mechanical analyses of principal soils in the survey area.

As shown in table 9, the $B_2$ horizons of the Pullman soils contain much more clay than the A horizons. These strongly developed soils have pronounced clay skins in the $B_2$ horizons. Laboratory studies of the Amarillo soils in Curry County show that these soils have a high percentage of clay in the $B_2$ horizon.

In general, for the soils with noncalcareous A and B horizons, a factor of 0.6 times the percentage of clay gives the approximate cation-exchange capacity. In contrast, for the sample of the calcareous Mansker soil, a factor of 0.25 times the percentage of clay gives the approximate cation-exchange capacity. The Mansker soils have little profile development and contain from 16 to 58 percent calcium carbonate.

The approximate cation-exchange capacity of the layers of soft caliche underlying the Pullman and Springer soils also equals about 0.25 times the percentage of clay. These layers of soft caliche contain from 44 to 62 percent calcium carbonate. Obviously, in soils that are strongly calcareous or that have a layer of soft caliche, a high percentage of the material reported as clay is calcium carbonate that occurs in clay-size particles. This material, known as rock flour, appears to have little or no cation-exchange capacity. Preliminary core studies show that its permeability and shrink-swell potential is like that of material from medium-textured soils. Therefore,

TABLE 9.—*Laboratory data on typical profiles of principal soils* [1]

| Soil type, pit-sample number, and kind of plant cover | Horizon | Depth | Size class and diameter of particles: Sand (2.0–0.05 millimeters) | Size class and diameter of particles: Silt (0.05–0.002 millimeter) | Size class and diameter of particles: Clay (less than 0.002 millimeter) | pH of saturated paste | Organic carbon | Nitrogen |
|---|---|---|---|---|---|---|---|---|
| | | *Inches* | *Percent* | *Percent* | *Percent* | | *Percent* | *Percent* |
| Manwood loam (mapped as Manwood-Pullman loams); P.S. 7; buffalograss and blue grama. | $A_1$ | 1–3 | 57 | 25 | 18 | 6.6 | 1.10 | 0.104 |
| | $A_2$ | 3–5 | 40 | 33 | 27 | 6.2 | 1.01 | .082 |
| | $B_{21}$ | 5–10 | 22 | 26 | 52 | 7.3 | .92 | .092 |
| | $B_{22}$ | 10–15 | 19 | 34 | 47 | 8.0 | .72 | .063 |
| | $B_2C_{2a}$ | 15–20 | 14 | 37 | 49 | 7.9 | .50 | .043 |
| | C | 20+ | [2] | [2] | [2] | [2] | [2] | [2] |
| Mansker loam; P.S. 10; blue grama and buffalograss. | A | 1½–6 | 35 | 35 | 30 | [2] | 1.69 | .163 |
| | $A_{ca}$ | 6–12 | 28 | 35 | 37 | 7.6 | 1.27 | .134 |
| | $C_{ca1}$ | 12–16 | 18 | 38 | 44 | 7.6 | .68 | .072 |
| | $C_{ca2}$ | 16–35 | 14 | 43 | 43 | 7.9 | .24 | .034 |
| | $B_{1cab}$ | 35–44 | 18 | 39 | 43 | 8.1 | .11 | .017 |
| | $B_{2cab}$ | 44–54 | 26 | 37 | 37 | 8.1 | .06 | .028 |
| | $B_{3cab}$ | 54–73 | 26 | 37 | 37 | 8.0 | .05 | .024 |
| | $C_{cab}$ | 73–88 | 20 | 34 | 46 | 8.1 | .11 | .013 |
| | $B_{cab}$ | 88–100 | 25 | 32 | 43 | 8.1 | .07 | .011 |
| Pullman loam; P.S. 2; wheat | $A_p$ | 0–6 | 41 | 38 | 21 | 6.8 | .75 | .083 |
| | $B_1$ | 6–13 | 32 | 35 | 33 | 7.0 | .65 | .082 |
| | $B_{21}$ | 13–26 | 21 | 39 | 40 | 7.4 | .43 | .060 |
| | $B_{22}$ | 26–40 | 29 | 36 | 35 | 7.7 | .22 | .045 |
| | $B_3$ | 40–54 | 34 | 34 | 32 | 7.9 | .17 | .033 |
| | $C_{ca}$ | 54–66 | 19 | 39 | 42 | 7.8 | .10 | .018 |
| | C | 66–118 | 26 | 37 | 37 | 7.8 | .08 | .015 |
| Pullman loam; P.S. 13; blue grama and buffalograss. | $A_1$ | 1–4 | 34 | 49 | 17 | 6.9 | 1.26 | .109 |
| | $A_3$ | 4–8 | 41 | 37 | 22 | 6.6 | .86 | .086 |
| | $B_1$ | 8–15 | 35 | 36 | 29 | 6.7 | .74 | .078 |
| | $B_{21}$ | 15–25 | 30 | 35 | 35 | 7.1 | .52 | .064 |
| | $B_{22}$ | 25–33 | 32 | 35 | 33 | 7.3 | .24 | .053 |
| | $B_{2ca}$ | 33–40 | 34 | 35 | 31 | 7.7 | .18 | .041 |
| | $B_{3ca}$ | 40–56 | 42 | 28 | 30 | 7.7 | .12 | .030 |
| | $C_{ca}$ | 60–84 | 28 | 36 | 36 | 7.9 | .10 | .015 |
| Pullman loam (mapped in Pullman-Mansker complexes) P.S. 1; cultivated crops. | $A_p$ | 0–2½ | 37 | 37 | 26 | 6.9 | 1.60 | .142 |
| | $A_3$ | 2½–7 | 32 | 38 | 30 | 6.9 | 1.96 | .181 |
| | $B_{21}$ | 7–14 | 28 | 37 | 35 | 7.0 | 1.06 | .108 |
| | $B_{22}$ | 14–20 | 24 | 37 | 39 | 7.3 | .70 | .082 |
| | $B_{3ca}$ | 20–26 | 28 | 36 | 36 | 7.7 | .48 | .062 |
| | $C_{ca}$ | 26–52 | 17 | 41 | 42 | 8.0 | .21 | .028 |
| | C | 52–64 | 22 | 42 | 36 | 8.1 | .24 | .025 |
| Springer fine sandy loam; P.S. 8; yucca and blue grama. | $A_1$ | ½–8 | 82 | 7 | 11 | 7.1 | .48 | .041 |
| | $B_2$ | 8–18 | 72 | 8 | 20 | 7.2 | .62 | .059 |
| | $B_3$ | 18–28 | 76 | 11 | 13 | 7.7 | .30 | .029 |
| | $B_{31}$ | 28–38 | 86 | 4 | 10 | 7.8 | .15 | .018 |
| | $A_{1b}$ | 38–45 | 80 | 7 | 13 | 7.8 | .13 | .025 |
| | $B_{2cab}$ | 45–53 | 72 | 6 | 22 | 7.9 | .18 | .031 |
| | $C_{ca}$ | 53–80 | 36 | 34 | 30 | 8.1 | .14 | .020 |

See footnotes at end of table.

TABLE 9.—*Laboratory data on typical profiles of principal soils* [1]—Continued

| Soil type, pit-sample number, and kind of plant cover | C–N ratio | Electrical conductivity (Ec x $10^3$) | Calcium carbonate ($CaCO_3$) | Cation exchange capacity | Extractable cations | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Calcium | Magnesium | Sodium | Potassium |
| | | *Mmhos./cm.* | *Percent* | *meq./100 mg.* | *meq./100 mg.* | *meq./100 mg.* | *meq./100 mg.* | *meq./100 mg.* |
| Manwood loam (mapped as Manwood-Pullman loams); P.S. 7; buffalograss and blue grama. | 11 | 0. 7 | 0 | 12 | 6. 6 | 2. 8 | 0. 1 | 0. 6 |
| | 12 | . 4 | 0 | 13 | 6. 9 | 3. 2 | . 2 | . 5 |
| | 10 | . 9 | 0 | 30 | 17. 0 | 11. 3 | 2. 1 | . 6 |
| | 11 | 1. 4 | 5 | 28 | 26. 0 | 14. 2 | 3. 3 | . 5 |
| | 12 | 10. 0 | 3 | 29 | 36. 0 | 27. 6 | 7. 9 | . 5 |
| | (2) | (2) | (2) | (2) | (2) | (2) | (2) | (2) |
| Mansker loam; P.S. 10; blue grama and buffalograss. | 10 | . 6 | 16 | 18. 6 | 31. 0 | 1. 3 | . 1 | . 6 |
| | 10 | . 6 | 31 | 15. 8 | 26. 7 | 1. 4 | . 1 | . 3 |
| | 9 | . 6 | 55 | 12. 6 | 24. 5 | 1. 4 | . 1 | . 2 |
| | 7 | . 5 | 58 | 10. 6 | 21. 4 | 1. 5 | . 1 | . 1 |
| | 7 | . 5 | 45 | 14. 5 | 10. 0 | 4. 4 | . 3 | . 2 |
| | 2 | . 7 | 28 | 15. 8 | 21. 2 | 6. 2 | . 9 | . 4 |
| | 2 | 1. 0 | 21 | 17. 1 | 20. 6 | 6. 4 | 1. 0 | . 4 |
| | 8 | 1. 1 | 53 | 10. 4 | 17. 6 | 3. 9 | . 7 | . 2 |
| | 6 | 1. 2 | 34 | 13. 6 | 18. 2 | 5. 5 | 1. 0 | . 3 |
| Pullman loam; P.S. 2; wheat | 9 | . 7 | 0 | 13. 4 | 9. 0 | 2. 1 | . 1 | . 6 |
| | 8 | . 8 | 0 | 19. 5 | 13. 1 | 3. 6 | . 3 | . 5 |
| | 7 | . 5 | 0 | 23. 4 | 15. 5 | 5. 4 | . 4 | . 8 |
| | 5 | . 6 | 2 | 19. 4 | 22. 4 | 5. 5 | 1. 1 | . 6 |
| | 5 | 1. 3 | 1 | 18. 6 | 19. 7 | 5. 5 | 1. 7 | . 5 |
| | 6 | 3. 8 | 53 | 10. 3 | 18. 6 | 3. 7 | 1. 7 | . 2 |
| | 5 | 3. 9 | 24 | 14. 3 | 20. 9 | 3. 8 | 1. 8 | . 3 |
| Pullman loam; P.S. 13; blue grama and buffalograss. | 12 | . 45 | 0 | 13. 8 | 8. 3 | 2. 0 | . 4 | . 8 |
| | 10 | . 47 | 0 | 12. 6 | 7. 7 | 2. 2 | . 1 | . 5 |
| | 10 | . 86 | 0 | 16. 8 | 10. 5 | 3. 2 | . 1 | . 5 |
| | 8 | . 45 | 0 | 22. 1 | 13. 2 | 4. 8 | . 2 | . 7 |
| | 4 | . 38 | 0 | 20. 2 | 13. 5 | 5. 4 | . 2 | . 2 |
| | 4 | . 48 | 3 | 17. 3 | 25. 6 | 5. 1 | . 4 | . 6 |
| | 4 | . 63 | 4 | 15. 1 | 20. 4 | 7. 9 | . 6 | . 4 |
| | 7 | 2. 40 | 44 | 8. 9 | 21. 5 | 3. 4 | . 9 | . 2 |
| Pullman loam (mapped in Pullman-Mansker complexes) P.S. 1; cultivated crops. | 11 | 1. 0 | 0 | 18. 9 | 14. 2 | 2. 4 | . 2 | 1. 3 |
| | 11 | 1. 3 | 0 | 22. 4 | 15. 8 | 2. 8 | . 2 | 1. 4 |
| | 10 | . 7 | 0 | 22. 5 | 17. 3 | 2. 7 | . 2 | . 9 |
| | 8 | . 6 | 1 | 26. 0 | 22. 0 | 4. 4 | . 1 | . 8 |
| | 8 | . 2 | 6 | 20. 0 | 27. 3 | 2. 5 | . 2 | . 6 |
| | 8 | . 8 | 62 | 8. 8 | 18. 1 | 2. 2 | . 2 | . 7 |
| | 10 | 1. 0 | 45 | 12. 3 | 19. 6 | 6. 0 | . 8 | . 3 |
| Springer fine sandy loam; P.S. 8; yucca and blue grama. | 12 | . 5 | 0 | 7. 5 | 6. 2 | 1. 1 | . 1 | . 3 |
| | 10 | . 6 | 0 | 12. 0 | 10. 5 | 1. 3 | . 1 | . 3 |
| | 10 | . 6 | 0 | 9. 3 | 8. 6 | 1. 3 | . 1 | . 2 |
| | 8 | . 5 | 0 | 7. 3 | 6. 0 | 1. 5 | . 1 | . 2 |
| | 5 | . 5 | 0 | 9. 2 | 12. 6 | 1. 7 | . 1 | . 3 |
| | 6 | . 4 | 4 | 13. 7 | 23. 3 | 3. 2 | . 1 | . 3 |
| | 7 | . 5 | 52 | 8. 7 | 21. 1 | 2. 7 | . 2 | . 1 |

[1] Percentage of organic carbon determined by potassium dichromate method; based on 77 percent recovery calculated to 100 percent. Extractable cations determined as follows: Calcium and magnesium by the versenate method; nitrogen by precipitation with uranyl magnesium acetate; and potassium by potassium permanganate titration.

[2] Not sampled.

layers of the calcareous Mansker soils and soft-caliche layers of other soils, which have clay loam texture according to pipette analyses, will have different properties from layers of less calcareous clay loam.

Although the surface soils of the Pullman and Springer soils are noncalcareous, the dominant cation is calcium, just as in calcareous soils such as the Mansker. Exchangeable magnesium is second to calcium. The percentage of exchangeable sodium is low in all soils, even in the Manwood. The greatest amount of exchangeable sodium is in the $B_2$ horizon of the Manwood soil.

Except for the Manwood soil, the surface layer of the soils has value and chroma darker than 5/3 when dry and 3/3 when moist. Although the soils are relatively dark, the percentage of organic carbon in the surface layers ranges from 0.48 to 1.69 percent. Carbon-nitrogen ratios in the A horizons range from 9 to 12. Nevertheless, nitrogen is a limiting factor in irrigation farming. In seasons of abundant rainfall, nitrogen may be limited on soils used for dryland farming.

## *General Nature of the Area*

The part of the High Plains in which the survey area occurs is known as *Llano Estacado*, or staked plains. The land is so nearly level that when the pioneers crossed

the area they had to mark their route with stakes. Otherwise, they would lose their way.

In a report written in 1849, Capt. R. B. Marcy, an army officer, says of the High Plains—

> . . . a view boundless as the ocean. Not a tree, shrub or any other object either animate or inanimate relieved the dreary monotony of the prospect; it was a vast illimitable expanse of desert prairie, the dread *Llano Estacado* or in other words the great Sahara of North America . . . even the savages dare not venture to pass it except in two or three places where they know water can be found.

Cattlemen first settled this area in the early 1860's, even though it was then inhabited by the Comanche Indians. Buffalo hunting was a major enterprise in 1870, but in the next 15 years most of the buffalo were killed.

Several railroads were built through localities near the survey area in the early 1900's. This stimulated homesteading, and by 1909 homesteads of 160 acres occupied much of the survey area. In the years that followed, as the need for larger farms and ranches increased, the homesteads were consolidated into larger holdings.

Cattle raising and growing of dry-farmed crops are the main agricultural enterprises. Most of the farms in the survey are combination grain and livestock farms. The eastern two-thirds of the survey area is used mainly for wheat farming, and the drier western one-third, mostly for ranching. Wheat and sorghums are the main crops, though barley and rye are grown occasionally. The sorghums are best suited to the sandy soils, and the wheat, to soils that contain more clay and silt.

Statistics on the number and average size of farms are not available for the survey area, but Federal census data for Quay County indicate trends within the area. For the county, the average size of the farm unit has increased gradually from 936 acres in 1920 to 2,222 acres in 1954. There has been a corresponding decrease in number of farms. The average dryland farm in this area covers about 2,000 acres. Some of the ranches cover 20,000 acres.

## Physiography, Relief, and Drainage

Most of the survey area is at the western edge of the southern High Plains. Two small areas, however, are 500 to 800 feet below the rough, broken caprock escarpment that marks the western boundary of the High Plains. One, in the northwestern corner of the survey area, covers about 15 square miles; the other, in the southwestern corner, covers about 40 square miles.

The High Plains area has long, undulating slopes, most of which have a grade of less than 2 percent to the southeast. More strongly sloping areas are near many playas and along Blanco Creek and Alamosa Creek, the two main streams.

On the High Plains, much of the drainage water flows into the playas. These enclosed basins contain water only a small part of the time. Alamosa Creek, which drains much of the west-central part of the survey area, empties into a large wet-weather lake that seldom overflows. Blanco Creek flows from the central part southeastward into Texas; it forms the headwaters of the Red River.

In the area below the escarpment in the northwestern corner of the survey area, drainage water flows into Alamogordo Creek; this creek empties into the Pecos River to the west of Quay County. From a strip about 200 to 300 feet wide above the escarpment that marks the northern boundary of the survey area, water drains northward into the watershed of the Canadian River. In the area in the southwestern corner, drainage water flows into Truchas Creek and on into the Pecos River.

## Climate

The climate of the survey area is semiarid. Summers are long and warm. Winters are mild, but there are short cold spells. No official weather station is maintained in the area, but climatic data recorded at the United States Weather Bureau in Clovis, Curry County, are fairly representative of the survey area. Table 10 shows the normal monthly, seasonal, and annual temperatures and precipitation. Monthly and annual precipitation over a 45-year period, 1911 through 1955, are given in table 11.

TABLE 10.—*Temperature and precipitation at Clovis, Curry County, N. Mex.*

[Elevation, 4,280 feet]

| Month | Temperature [1] | | | Precipitation [2] | | | |
|---|---|---|---|---|---|---|---|
| | Average | Absolute maximum | Absolute minimum | Average | Driest year (1917) | Wettest year (1941) | Average snowfall |
| | °F. | °F. | °F. | Inches | Inches | Inches | Inches |
| December | 37. 9 | 78 | −9 | 0. 58 | 0 | 0. 43 | 3. 1 |
| January | 36. 9 | 77 | −8 | . 39 | . 44 | . 33 | 2. 3 |
| February | 41. 5 | 81 | −17 | . 39 | . 06 | . 25 | 1. 7 |
| Winter | 38. 8 | 81 | −17 | 1. 36 | . 50 | 1. 03 | 7. 1 |
| March | 47. 1 | 90 | −4 | . 59 | . 07 | 2. 48 | 1. 7 |
| April | 57. 0 | 99 | 12 | 1. 28 | . 57 | 3. 43 | . 5 |
| May | 65. 9 | 101 | 26 | 2. 36 | 1. 13 | 11. 67 | . 1 |
| Spring | 56. 7 | 101 | −4 | 4. 23 | 1. 77 | 17. 78 | 2. 3 |
| June | 74. 9 | 109 | 36 | 2. 62 | 0 | 8. 57 | (3) |
| July | 78. 5 | 109 | 52 | 2. 49 | 2. 35 | 4. 60 | (3) |
| August | 77. 2 | 110 | 46 | 2. 90 | 1. 77 | 2. 02 | (3) |
| Summer | 76. 9 | 110 | 36 | 8. 01 | 4. 12 | 15. 19 | (3) |
| September | 69. 9 | 105 | 31 | 2. 25 | 1. 10 | 6. 79 | (3) |
| October | 59. 0 | 98 | 13 | 1. 85 | 0 | 5. 96 | . 2 |
| November | 46. 4 | 85 | 0 | . 49 | . 07 | . 16 | 1. 3 |
| Fall | 58. 4 | 105 | 0 | 4. 59 | 1. 17 | 12. 91 | 1. 5 |
| Year | 57. 7 | 110 | −17 | 18. 19 | 7. 56 | 46. 91 | 10. 9 |

[1] Average temperature based on a 38-year record, through 1955; highest temperature on a 40-year record, and lowest temperature on a 39-year record, through 1952.

[2] Average precipitation based on a 42-year record, through 1955; wettest and driest years based on a 45-year record, in the period 1911–55; snowfall based on a 40-year record, through 1952.

[3] Trace.

TABLE 11.—*Monthly and annual precipitation at Clovis, Curry County, N. Mex.*

| Year | January | February | March | April | May | June | July | August | September | October | November | December | Annual |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *Inches* | *Inches* | *Inches* | *Inches* | *Inches* | *Inches* | *Inches* | *Inches* | *Inches* | *Inches* | *Inches* | *Inches* | *Inches* |
| 1911 | 0.13 | 1.13 | 0.98 | 1.42 | 2.25 | 0.40 | 3.39 | 2.23 | 1.67 | 1.01 | 0.25 | 1.56 | 16.42 |
| 1912 | 0 | 2.05 | .38 | .20 | 3.05 | 1.07 | .78 | 6.26 | 3.72 | .37 | 0 | .07 | 17.95 |
| 1913 | .21 | .82 | .04 | 1.61 | .12 | 5.39 | 1.62 | 1.62 | 1.69 | .76 | .91 | 1.16 | 15.95 |
| 1914 | 0 | .04 | .04 | 3.33 | 6.59 | 1.23 | 1.95 | 1.71 | .84 | 3.40 | .35 | .52 | 20.00 |
| 1915 | .25 | 1.01 | 1.38 | 6.77 | .54 | 1.41 | 3.81 | 2.85 | 5.74 | 1.38 | .22 | 1.53 | 26.89 |
| 1916 | .44 | 0 | .45 | 2.14 | .40 | .93 | .57 | 7.45 | 2.37 | 2.04 | .05 | .86 | 17.70 |
| 1917 | .44 | .06 | .07 | .57 | 1.13 | 0 | 2.35 | 1.77 | 1.10 | 0 | .07 | 0 | 7.56 |
| 1918 | .25 | .06 | .20 | .95 | 2.07 | 1.54 | 2.66 | 2.50 | 1.36 | 2.99 | .70 | 1.18 | 16.46 |
| 1919 | .13 | [1] | 2.71 | 2.93 | 3.00 | 1.98 | 2.88 | .52 | 4.97 | 1.51 | .58 | .42 | 21.63 |
| 1920 | .65 | .11 | .38 | .01 | 1.71 | 4.30 | 1.60 | 6.11 | 1.20 | .94 | .59 | .10 | 17.70 |
| 1921 | 1.33 | .37 | .20 | 0 | 1.98 | 5.85 | 6.98 | .99 | 2.27 | [1] | 0 | 0 | 19.97 |
| 1922 | .08 | .12 | .66 | 3.68 | 1.17 | 4.97 | .54 | 1.82 | .27 | [1] | .50 | [1] | 13.81 |
| 1923 | 0 | 1.39 | 1.70 | 2.86 | .82 | 12.31 | .99 | 1.25 | 1.85 | 9.93 | 1.66 | 1.30 | 36.06 |
| 1924 | .05 | .37 | .77 | .23 | .65 | 1.89 | 1.88 | 2.82 | 1.12 | 1.00 | .40 | .13 | 11.31 |
| 1925 | .04 | 0 | 0 | .24 | 1.25 | 2.42 | 3.44 | 4.78 | 3.57 | 1.13 | .05 | .07 | 16.99 |
| 1926 | .13 | [1] | 3.10 | 2.46 | 3.89 | 1.92 | 1.32 | 3.23 | 2.99 | 1.47 | .34 | 1.08 | 21.93 |
| 1927 | .08 | .31 | [1] | .14 | .24 | 2.79 | 2.31 | 4.20 | 3.94 | .71 | [1] | .24 | 14.96 |
| 1928 | 0 | 1.03 | [1] | .10 | 4.61 | 4.18 | 5.21 | 3.91 | .25 | 4.60 | .68 | .52 | 25.09 |
| 1929 | [1] | .25 | 1.27 | .10 | 3.06 | 1.26 | .76 | 1.65 | 1.49 | 1.83 | .81 | [1] | 12.48 |
| 1930 | .31 | [1] | .48 | 2.42 | 1.05 | 2.03 | 8.48 | 1.66 | 1.74 | 1.19 | .80 | .56 | 20.72 |
| 1931 | 1.46 | .52 | .62 | 3.09 | 1.06 | .60 | 3.06 | 4.87 | 3.41 | .70 | 1.68 | 1.15 | 22.22 |
| 1932 | .57 | .49 | .32 | 1.17 | 2.45 | 4.00 | 1.27 | 7.38 | 3.83 | .46 | 0 | .86 | 22.80 |
| 1933 | 1.04 | .54 | .21 | 0 | 2.03 | .29 | 2.81 | 3.30 | 1.85 | .08 | .11 | 0 | 12.26 |
| 1934 | 0 | .32 | .97 | 1.73 | .93 | 1.53 | 2.19 | 1.30 | .67 | .69 | 1.36 | .08 | 11.77 |
| 1935 | .16 | .03 | .27 | .03 | 4.02 | 3.82 | 2.56 | 2.05 | .45 | [1] | 1.87 | .22 | 15.48 |
| 1936 | .80 | .10 | 0 | [1] | 7.00 | 1.98 | .69 | .61 | 6.88 | .99 | 0 | .30 | 19.35 |
| 1937 | .11 | .24 | 1.40 | .20 | 5.05 | 3.76 | 2.04 | 1.03 | 4.17 | 1.69 | [1] | .58 | 20.27 |
| 1938 | .52 | .95 | .96 | [1] | .98 | 3.45 | 3.66 | 1.23 | 3.46 | 5.00 | 0 | .11 | 20.32 |
| 1939 | 1.94 | .10 | .54 | .50 | 2.11 | 1.16 | .90 | 4.62 | .28 | 1.23 | .33 | .94 | 14.65 |
| 1940 | .26 | .31 | [1] | .95 | 2.62 | 1.01 | .45 | 1.51 | .48 | .86 | 1.76 | .11 | 10.32 |
| 1941 | .35 | .25 | 2.48 | 3.43 | 11.87 | 8.57 | 4.60 | 2.02 | 6.79 | 5.96 | .16 | .43 | 46.91 |
| 1942 | [1] | .59 | .03 | 2.64 | .79 | 1.30 | 1.87 | 7.01 | .64 | 6.27 | 0 | 1.19 | 22.33 |
| 1943 | 0 | 0 | 0 | .10 | 1.01 | .48 | .91 | .89 | .87 | .10 | .60 | 2.62 | 7.58 |
| 1944 | .20 | .52 | 0 | 1.12 | 1.48 | 2.51 | .86 | 3.11 | 2.03 | .61 | .69 | 1.06 | 14.19 |
| 1945 | .59 | .26 | .17 | .16 | .33 | [1] | 2.79 | 1.48 | 3.02 | .69 | [1] | .04 | 9.53 |
| 1946 | .64 | .09 | .16 | .66 | .31 | 1.16 | 1.77 | 2.39 | 2.88 | 5.16 | .53 | .41 | 16.16 |
| 1947 | .65 | .09 | .56 | 1.32 | 3.23 | .06 | 1.15 | 2.36 | .24 | .42 | .76 | 1.06 | 11.90 |
| 1948 | .37 | 1.25 | .28 | .25 | 1.04 | 2.59 | 1.32 | 3.47 | .48 | .27 | .58 | .21 | 12.11 |
| 1949 | 1.23 | .65 | .29 | .52 | 5.58 | 5.29 | 2.07 | 3.82 | 1.53 | 2.44 | .13 | .57 | 24.12 |
| 1950 | [1] | .02 | [1] | .41 | .83 | 3.46 | 8.96 | 2.31 | 1.80 | .97 | [1] | .05 | 18.81 |
| 1951 | .70 | .74 | .19 | .12 | 3.52 | 2.31 | 1.86 | 1.09 | .20 | 1.86 | .38 | .57 | 13.54 |
| 1952 | .54 | .29 | .26 | 3.06 | .37 | 2.13 | 2.18 | 1.00 | .85 | 0 | 1.25 | .40 | 12.33 |
| 1953 | .68 | .77 | .23 | 1.09 | 1.09 | .03 | 2.82 | 3.23 | 0 | 1.61 | .37 | .30 | 12.22 |
| 1954 | .22 | .62 | .10 | .86 | 1.34 | 1.06 | .50 | 6.13 | .14 | 3.65 | .02 | .22 | 14.86 |
| 1955 | .30 | 0 | .01 | .80 | 2.10 | 2.66 | 4.37 | .58 | 1.49 | .43 | .02 | .03 | 12.79 |
| Average [2] | 0.40 | 0.42 | 0.55 | 1.25 | 2.28 | 2.51 | 2.47 | 2.85 | 2.06 | 1.73 | 0.48 | 0.57 | 17.56 |

[1] Trace.

[2] Average rounded to two decimal places.

In using information in tables 10 and 11, remember that Clovis is on the High Plains and in climatic zone 3; the data, therefore, are most representative of that part of this survey area in climatic zone 3. (See map of climatic zones on page 20.) The area west of Alamosa Creek, in climatic zone 4, receives less precipitation than the area in zone 3. Areas below the caprock in the western part of the survey area, in climatic zone 5, receive the least amount of precipitation.

The average annual precipitation within the survey area ranges between 15 and 19 inches. Of this, approximately 75 percent falls during the growing season. Little precipitation falls in winter, and most of it is in the form of snow.

The effect of the precipitation on agriculture depends, in part, on the length and intensity of the rainstorms and on how the rainfall is distributed over the year. Light showers usually are of little benefit to plants. The moisture evaporates before it can soak into the soil. Approximately one-fourth of the precipitation falls in amounts of less than one-half inch. Variations in both seasonal and monthly rainfall are great; therefore, long droughts are common.

The average annual temperature at Clovis is about 58° F. The highest temperature recorded was 110°, and the lowest was −17°. The average frost-free period is 197 days. In spring the average date for the last killing frost is April 15; in fall the average date for the first killing frost is October 29.

Evaporation from a free water surface is very high. From April 1 through September 30, the evaporation rate averages about 56 inches. Records of the Plains Substation near Clovis indicate that the yearly evaporation is often 100 inches.

The average wind velocity is low, but windstorms occur often during winter and spring, particularly during February, March, and April. Although the prevailing winds are from the southwest, severe windstorms may come from any direction, especially the west, northwest, and north. The storms generally last for several hours; the wind reaches 60 miles per hour, with gusts of higher velocity. Windstorms may result in severe soil blowing in unprotected areas.

## Water Supply

All water for domestic use is drawn from wells by windmills or electric pumps. In most of the area, the average well is 300 feet deep. The water is free of excessive amounts of salts and is of good quality. The supply is adequate. Where feasible, tanks catch runoff for watering livestock. Most of these tanks do not provide a permanent source of water, but they help to keep livestock distributed properly.

Near the town of House and along Alamosa Creek, water is more abundant and closer to the surface. Here, pump irrigation is practiced on about 6,000 acres. Gasoline engines pump the water from depths of 30 to 90 feet; the average lift is about 55 feet. Five- to ten-inch pumps are used. The delivery ranges from 300 to 400 gallons of water per minute. The water basin underlying the soils is small, and the rate of drawdown is rapid.

The rate at which underground water is being restored (recharge) is also rapid, however. Alamosa Creek is the main source of recharge.

## Vegetation

Most of the survey area lies in the drier part of the High Plains, in what is dominantly short-grass country. Blue grama, buffalograss, and ring muhly, in that order, are the principal grasses. Above the caprock native vegetation provides good grazing. In areas below the caprock the native vegetation is also suitable.

Tree cactus, cholla cactus, and yucca are the dominant shrubs throughout the area, but there are shrubs of many other kinds. Pinon pine and juniper grow only on the breaks bordering the caprock escarpment. Dense stands of these trees occur in some places.

For a more detailed description of the vegetation in the survey area, turn to the section, Range Management.

## Community Facilities

All parts of the survey area have adequate roads, including five paved State highways and two hard-surfaced highways. Most county roads are graded and drained: few farms are more than a short distance from a good highway. No railroads or Federal highways cross the survey area, and, consequently, there are no large marketing centers.

A principal market is located 25 miles to the north at Tucumcari, the county seat of Quay County. Another is at Clovis, Curry County, 40 miles to the southeast. House is the main market within the survey area; it had a population of 144 in 1950. Other communities are Wheatland, Forrest, Ragland, and McAlister. At each of these places, there is a general store and a filling station.

There are churches of different denominations throughout the area. Grade and high schools are located at House and Forrest, and there is a grade school at Wheatland. Between 1950 and 1956, school enrollment declined 34 percent. As a result, several schools have been consolidated recently. Buses transport the students to school.

# *Glossary*

**Aggregate (of soil).** Many fine soil particles held in a single mass or cluster, such as a clod, crumb, block, or prism. Many properties of the aggregate differ from those of an equal mass of unaggregated soil.

**Alkaline soil.** A soil that has an alkaline reaction; that is, a soil for which the pH reading of the saturated soil paste is higher than 7.

**Alluvium** (alluvial deposits). Soil materials deposited on land by streams.

**Border ridge.** A ridge of earth constructed to confine the flow of water in border irrigation to a given area.

**Calcareous soil.** Soil that contains enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) when treated with dilute hydrochloric acid. Soil that is alkaline in reaction because of the presence of free calcium carbonate.

**Caliche.** A broad term for more or less strongly cemented deposits of calcium carbonate in many soils of warm-temperate areas. When at or near the surface, the material hardens.

**Chisel.** A tillage machine that has one or more soil-penetrating points that can be drawn through the soil to loosen or shatter the subsoil to various depths up to 36 inches.

**Chlorosis.** A condition in plants resulting from the failure of chlorophyll (the green coloring matter) to develop, usually because of deficiency of an essential nutrient. Leaves of chlorotic plants range from light green through yellow to almost white.

**Clay.** As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil that contains 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

**Clay skin (clay film).** A dark-colored film of fine clay that coats the surfaces and pores of soil aggregates in many strongly developed soils. It occurs predominantly in the B horizon and consists of clay leached from horizons above.

**Climax vegetation.** The final stage of plant succession for a given natural environment; the stage at which the composition of the plant community remains unchanged and can reproduce itself as long as the environment remains unchanged.

**Complex, soil.** An association in which two or more soils are so intricately intermixed that it is not practical to show them separately at the scale of mapping used.

**Consistence, soil.** The nature of soil material that is expressed by the resistance of the individual particles to separation from one another (cohesion) or by the ability of a soil mass to undergo a change in shape without breaking (plasticity). The consistence varies with the moisture content. Thus, a soil aggregate or clod may be hard when dry and plastic when wet. Terms used to describe consistence are—

*Friable.* When moist, easily crushed by hand and coheres when pressed together Friable soils are easily tilled.

*Firm.* When moist, crushes under moderate pressure but resistance is distinctly noticeable. Firm soils are likely to be difficult to till.

*Hard.* When dry, is moderately resistant to pressure; can be broken in the hands without difficulty but is barely breakable between thumb and forefinger.

*Indurated.* Hard, very strongly cemented; brittle; does not soften under prolonged wetting.

*Loose.* Noncoherent when moist or dry; loose soils are generally coarse textured and are easily tilled.

**Drawdown.** The inverted cone-shaped area of water depletion, below the level of the static water table, that occurs temporarily after an irrigation well has been pumped for a considerable time.

**Dryland farming.** Generally, producing crops that require at least some tillage, without irrigation, in subhumid to semiarid areas.

**Fallow.** Cropland left idle in order to restore productivity, mainly through accumulation of water, nutrients, or both. Summer fallow is a common stage before planting of cereal grain in regions of limited rainfall. In fallowing, soil is tilled for at least one growing season to control weeds, to aid decomposition of plant residues, and to encourage storage of moisture for the succeeding grain crop.

**Great soil group.** Any one of several broad groups of soils with fundamental characteristics in common.

**Horizon, soil.** A layer of soil, approximately parallel to the soil surface, that has characteristics produced by soil-forming processes. The relative positions of the several soil horizons in the soil profile and their nomenclature are given below—

*Horizon A.* The master horizon consisting of (1) one or more mineral horizons of maximum organic accumulation; or (2) surface or subsurface horizons that are lighter in color than the underlying horizon and which have lost clay minerals, iron, and aluminum with resultant concentration of the more resistant minerals; or (3) horizons belonging to both categories.

*Horizon B.* The master horizon of altered material characterized by (1) an accumulation of clay, iron, or aluminum, with accessory organic material; or (2) blocky or prismatic structure together with other characteristics, such as stronger colors, unlike those of the A horizons, or the underlying horizons of nearly unchanged material; or (3) characteristics of both these categories. Commonly, the lower limit of the B horizon corresponds to the lower limit of the solum, true soil.

*Horizon C.* A layer of unconsolidated material, relatively little affected by the influence of organisms and presumed to be similar in chemical, physical, and mineralogical composition to the material from which at least a part of the overlying solum has developed.

*Horizon D.* Any stratum underlying the C, or the B if no C is present, which is unlike the C, or unlike the material from which the solum has been formed.

**Listing.** A type of tillage in which the plowshares throw the soil in opposite directions and leave the field with alternate ridges and furrows. This type of tillage is used on the High Plains to form a roughened surface for protection against wind erosion.

**Loam.** The textural class name for soil having a moderate amount of sand, silt, and clay. Loam soils contain 7 to 27 percent of clay, 28 to 50 percent of silt, and less than 52 percent of sand.

**Loess.** Geological deposit of fairly uniform fine material, mostly silt, presumably transported by wind.

**Parent material.** The unconsolidated material from which the soil develops.

**Permeability, soil.** That quality of the soil that enables it to transmit air and water. Moderately permeable soils transmit air and water readily, and this favors root growth. *Slowly permeable* soils allow water and air to move so slowly that root growth may be restricted. *Rapidly permeable* soils transmit air and water readily, and root growth is good.

**Phase, soil.** A subdivision of the soil type covering variations that are chiefly in such external characteristics as relief, color, stoniness, or accelerated erosion.

**Playa.** A flat-bottomed, undrained basin that contains shallow water for short periods following rains.

**Plow layer.** That part of the soil profile in which tillage takes place.

**Profile, soil.** A vertical section of the soil through all of its horizons and extending into the parent material. (*See* Horizon, soil.)

**Range site.** Kinds of rangeland that differ from each other in their ability to produce a significantly different kind or amount of climax, or original, vegetation. A significant difference means one large enough to require different grazing use or management to maintain or improve the resource.

**Runoff.** Surface drainage of rain or melted snow.

**Sand.** (1) Individual rock or mineral fragments having diameters ranging from 0.05 millimeter (0.02 inch) to 2.0 millimeters (0.079 inch). Sand grains consist chiefly of quartz, but they may be any mineral composition. (2) The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

**Series, soil.** A group of soils that have genetic horizons that are, except for the texture of the surface soil, similar in differentiating characteristics and in arrangement in the soil profile, and that have developed from a particular type of parent material. A series may include two or more soil types that differ from one another in texture of the surface soil.

**Silt.** (1) Individual mineral particles of soil that range in diameter from the upper size of clay, 0.002 millimeter, to the lower size of very fine sand, 0.05 millimeter. (2) Soil of the textural class called silt contains 80 percent or more of silt and less than 12 percent clay.

**Soil association.** A group of soils, with or without characteristics in common, that occur in a regular geographical pattern.

**Slick spot.** A small area of alkali or Solonetz soil. Also known as scab spots.

**Solonetz soils.** An intrazonal group of soils having surface horizons of varying degrees of friability underlain by dark-colored hard soil, ordinarily with columnar structure (prismatic structure with rounded tops). This hard layer is usually highly alkaline. Such soils have developed under grass or shrub vegetation, mostly in subhumid or semiarid climates. This term is used for a broad group of soils that include many so-called alkali soils in the western part of the United States. (Where the hard, clayey layer is overlain with a light-colored leached layer, the soils are called solodized Solonetz.)

**Solum.** The part of the soil profile, above the unweathered parent material, in which the processes of soil formation are active. In mature soils the solum consists of the A and B horizons.

**Structure.** The arrangement of individual soil particles into aggregates with definite shape or pattern. Structure is described in terms of *class*, *grade*, and *type*.

*Class.* Refers to the size of the soil aggregates.

*Grade.* Distinctness and durability of the aggregates. Grade is expressed as *weak*, *moderate*, or *strong*. Soil that has no visible structure is termed *massive* if coherent, or *single grain* if noncoherent.

*Type.* Shape and arrangment of the aggregates. *Granular*, *blocky*, and *prismatic* types of structure predominate in soils of southwestern Quay County.

**Stubble mulch tillage.** A type of tillage used in areas subject to wind erosion. Subtillage sweeps loosen the subsoil and eradicate weeds but leave the crop stubble more or less undisturbed.

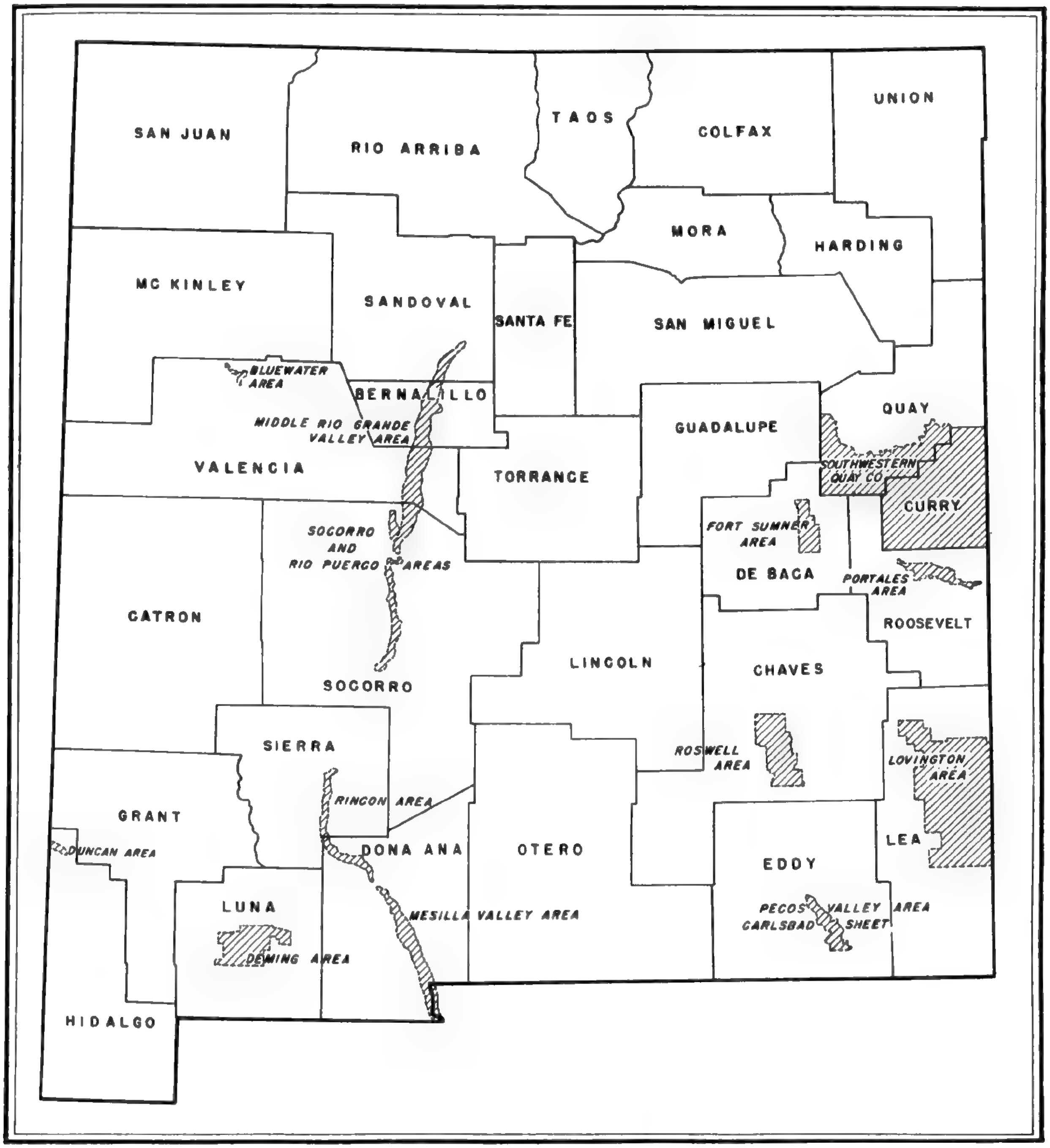
**Terrace.** (for control of runoff, or soil erosion, or both) An embankment or ridge constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surplus runoff to retard it for infiltration into the soil so that any excess may flow slowly to a prepared outlet without harm.

**Texture, soil.** The relative proportions of sand, silt, and clay particles in the soil. (*See* Sand; Clay; Silt.)

**Tillage pan.** A dense, highly compact zone occurring in the soil just below normal tillage depth; caused by tilling when the soil is too moist.

**Topography.** The physical land features, collectively, of an area.

**Type, soil.** A subgroup or category under the soil series based on the texture of the surface soil. A soil type is a group of soils having horizons similar in differentiating characteristics and arrangement in the soil profile and developed from a particular type of parent material. The name of a soil type consists of the name of the soil series plus the textural class name of the upper part of the soil equivalent to the surface soil. Thus Pullman loam is the name of a soil type within the Pullman series.




**Areas surveyed in New Mexico shown by shading.**

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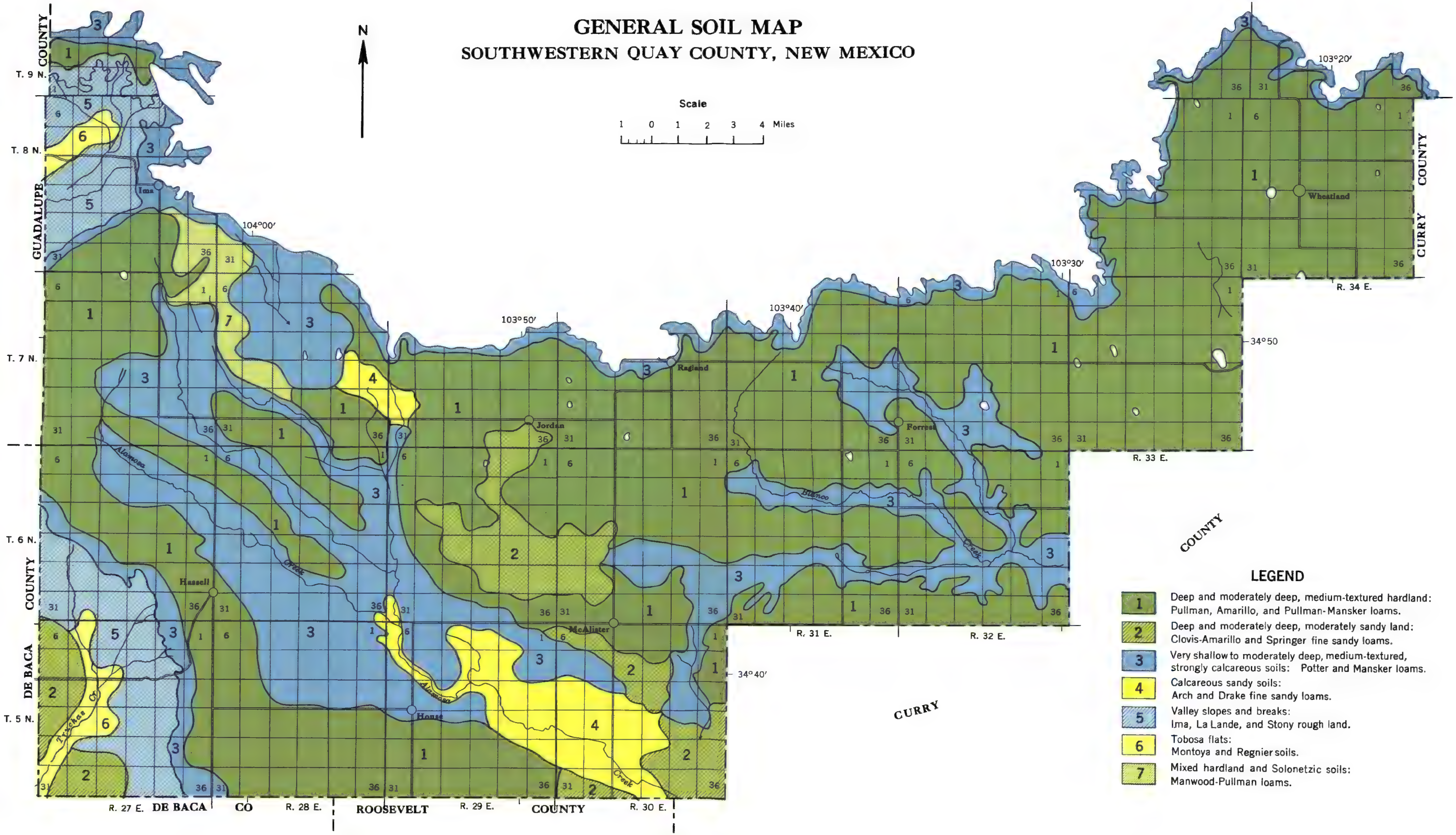
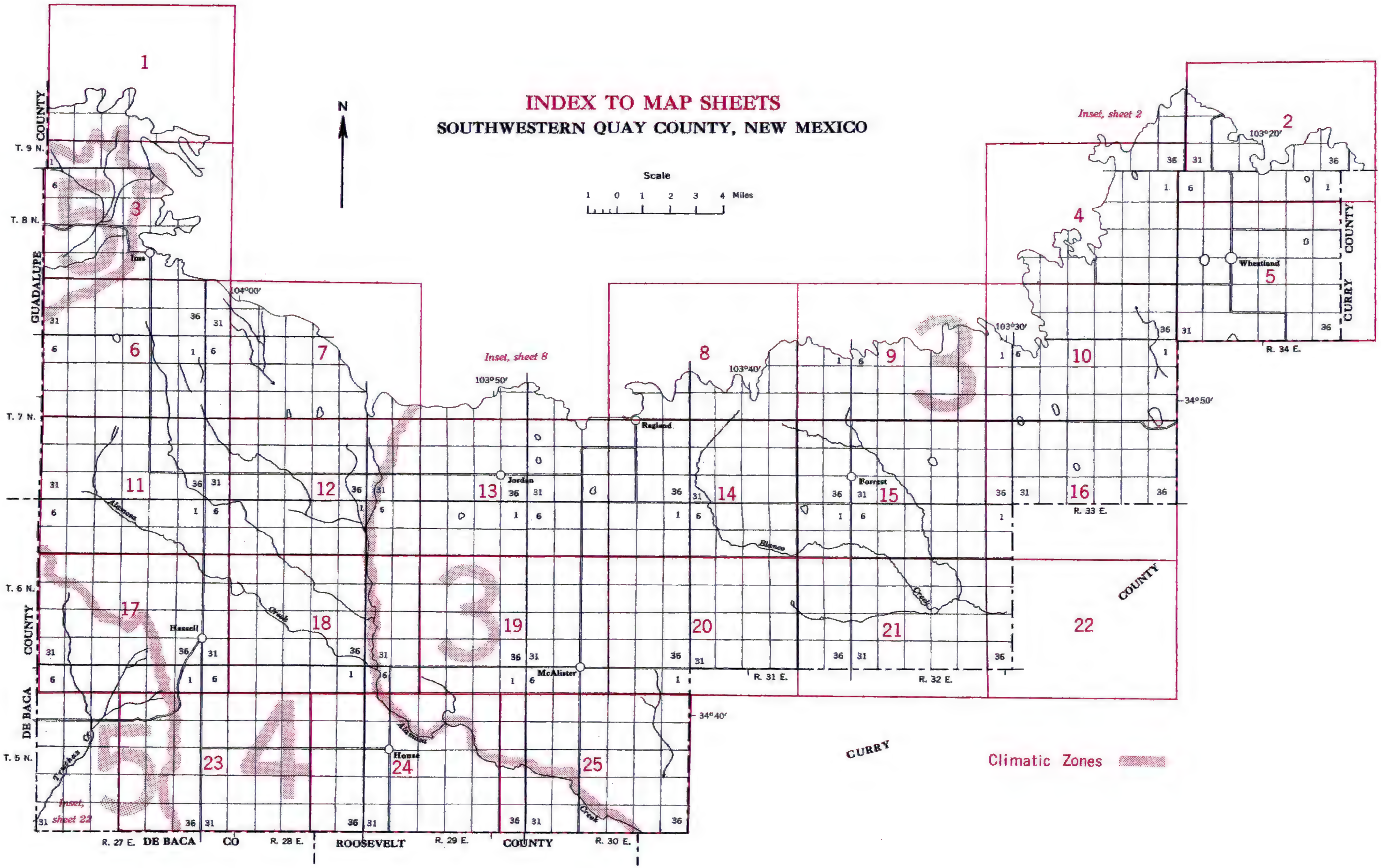
# GENERAL SOIL MAP
## SOUTHWESTERN QUAY COUNTY, NEW MEXICO





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CURRY COUNTY
CURRY
COUNTY
DE BACA CO
DE BACA COUNTY
ROOSEVELT COUNTY
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R. 32 E.
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R. 34 E.
104°00′
103°50′
103°40′
103°30′
103°20′
34°50′
34°40′
Ima
Wheatland
Ragland
Jordan
Forrest
Hassell
McAlister
House
Alamosa
Creek
Blanco
Creek
Tierra Blanca Cr.
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U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

# SOUTHWESTERN QUAY COUNTY, NEW MEXICO

NEW MEXICO AGRICULTURAL EXPERIMENT STATION

## SOIL LEGEND

| SYMBOL | NAME |
|---|---|
| Aa | Alama loam, 0-2 percent slopes |
| Ab | Alama loam, 2-5 percent slopes |
| Ac | Alama silt loam, 0-2 percent slopes |
| Ad | Alama silt loam, 2-5 percent slopes |
| Ae | Amarillo fine sandy loam, 0-2 percent slopes |
| Af | Amarillo fine sandy loam, 2-5 percent slopes |
| Ag | Amarillo loam, 0-2 percent slopes |
| Ah | Amarillo loam, 2-5 percent slopes |
| Ak | Amarillo loam, valleys, 0-2 percent slopes |
| Am | Amarillo loam, valleys, 2-5 percent slopes |
| An | Arch fine sandy loam |
| Ao | Arch loam |
| Ap | Arch loamy fine sand |
| Ar | Arvana fine sandy loam, shallow, 0-2 percent slopes |
| As | Arvana fine sandy loam, shallow, 2-5 percent slopes |
| At | Arvana loam, shallow, 0-2 percent slopes |
| Au | Arvana loam, shallow, 2-5 percent slopes |
| Ca | Church clay loam |
| Cb | Clovis-Amarillo fine sandy loams, 0-5 percent slopes |
| Cc | Clovis-Amarillo loams, 0-2 percent slopes |
| Cd | Clovis-Amarillo loams, 2-5 percent slopes |
| Ce | Clovis-Amarillo loams, valleys, 0-2 percent slopes |
| Cf | Clovis-Amarillo loams, valleys, 2-5 percent slopes |
| Da | Drake fine sandy loam, 2-10 percent slopes |
| Db | Drake loamy fine sand, 2-10 percent slopes |
| Ha | Hassell loam, 2-5 percent slopes |
| Ia | Ima gravelly loam, light-colored variant, 2-5 percent slopes |
| Ib | Ima gravelly loam, light-colored variant, 5-10 percent slopes |
| Ic | Ima loam, 0-2 percent slopes |
| Id | Ima loam, 2-5 percent slopes |
| La | La Lande loam, 0-2 percent slopes |
| Lb | La Lande loam, 2-5 percent slopes |
| Lc | Larimer gravelly loam |
| Ld | Lofton clay loam |
| Ma | Mansker fine sandy loam, 0-2 percent slopes |
| Mb | Mansker fine sandy loam, 2-5 percent slopes |
| Mc | Mansker fine sandy loam, 5-10 percent slopes |
| Md | Mansker loam, 0-2 percent slopes |
| Me | Mansker loam, 2-5 percent slopes |
| Mf | Mansker loam, 5-10 percent slopes |
| Mg | Manwood-Pullman loams |
| Mh | Montoya silty clay loam, 0-2 percent slopes |
| Mk | Montoya silty clay loam, 2-5 percent slopes |
| Na | Newkirk sandy loam, 2-10 percent slopes |
| Pa | Portales fine sandy loam, 0-2 percent slopes |
| Pb | Portales loam, 0-2 percent slopes |
| Pc | Potter fine sandy loam |
| Pd | Potter loam |
| Pe | Pullman loam, 0-2 percent slopes |
| Pf | Pullman loam, 2-5 percent slopes |
| Pg | Pullman-Mansker loams, 0-2 percent slopes |
| Ph | Pullman-Mansker loams, 2-5 percent slopes |
| Ra | Regnier silt loam |
| Rb | Riverwash |
| Rc | Rough broken and stony land |
| Sa | San Jose fine sand, moderately deep over sand, 0-2 percent slopes |
| Sb | San Jose fine sand, moderately deep over sand, 2-5 percent slopes |
| Sc | Springer fine sandy loam, 0-2 percent slopes |
| Sd | Springer fine sandy loam, 2-5 percent slopes |
| Se | Springer fine sandy loam, valleys, 0-5 percent slopes |
| Sf | Springer loamy fine sand, 0-5 percent slopes |
| Sg | Spur soils |
| Sh | Stony rough land, mixed materials |
| Sk | Stony rough land, Potter materials |
| Ta | Tivoli fine sand |
| Tb | Tucumcari loam, 0-2 percent slopes |
| Tc | Tucumcari loam, 2-5 percent slopes |

Soils surveyed 1954-56 by William A. Buchanan, J. A. Hughes, and Warren F. Johnson, Soil Conservation Service.
Correlation by Arvard J. Cline, Soil Conservation Service.

Soil map constructed 1958 by Cartographic Division, Soil Conservation Service, USDA, from 1951-52 aerial photographs. Controlled mosaic based on New Mexico plane coordinate system, east zone, transverse Mercator projection, 1927 North American datum.

## CONVENTIONAL SIGNS

### WORKS AND STRUCTURES

Roads
- Good motor
- Poor motor
- Trail
- Marker, U. S. — 33

Railroads
- Single track
- Multiple track
- Abandoned

Bridges and crossings
- Road
- Trail, foot
- Railroad
- Ferry
- Ford
- Grade
- R. R. over
- R. R. under
- Tunnel

Buildings
- School
- Church
- Station

Mine and Quarry
- Shaft
- Dump
- Prospect

Pits, gravel or other
Power line
Pipeline
Cemetery
Dam
Levee
Tank
Oil well
Windmill
Canal lock (point upstream)

### BOUNDARIES

- National or state
- County
- Township, civil
- Township, U. S.
- Section line, corner
- City (corporate)
- Reservation
- Land grant

### DRAINAGE

Streams
- Perennial
- Intermittent unclass.
- Crossable with tillage implements
- Not crossable with tillage implements

Canals and ditches — CANAL, DITCH

Lakes and ponds
- Perennial
- Intermittent

Wells — flowing
Springs
Marsh
Wet spot

### RELIEF

Escarpments
- Bedrock
- Other

Prominent peaks

Depressions (Large, Small)
- Crossable with tillage implements
- Not crossable with tillage implements
- Contains water most of the time

### SOIL SURVEY DATA

- Soil type outline and symbol — Dx
- Gravel
- Stones
- Rock outcrops
- Chert fragments
- Clay spot
- Sand spot
- Gumbo or scabby spot
- Made land

Erosion
- Uneroded spot — U
- Sheet, moderate — S
- Sheet, severe — SS
- Gully, moderate — G
- Gully, severe — GG
- Sheet and gully, moderate — SG
- Wind, moderate
- Wind, severe
- Blowout
- Wind hummock
- Overblown soil

Gullies

Areas of alkali and salts
- Strong — A
- Moderate — M
- Slight — S
- Free of toxic effect — F
- Sample location — 26
- Saline spot

SOUTHWESTERN QUAY COUNTY, NEW MEXICO - SHEET NUMBER 1
R. 27 E.

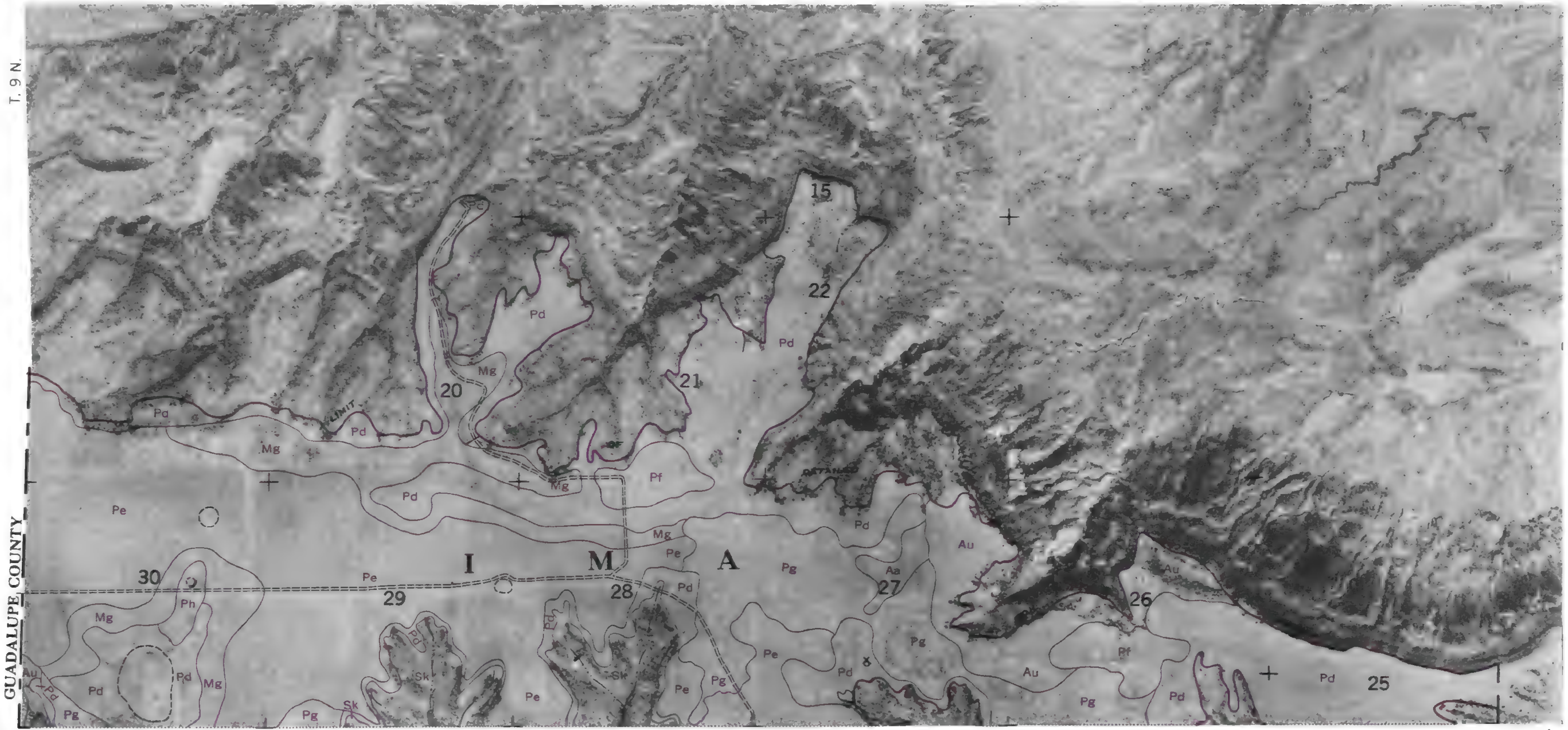
1

N

This is one of a set of maps prepared by the Soil Conservation Service, U. S. Department of Agriculture, for a soil survey report of this area. For information regarding the complete soil survey report, write the Soil Conservation Service, U. S. Department of Agriculture, Washington 25, D. C. This map compiled from aerial photographs flown in 1952.

Range, township, and section corners shown on this map are indefinite.

T. 9 N.

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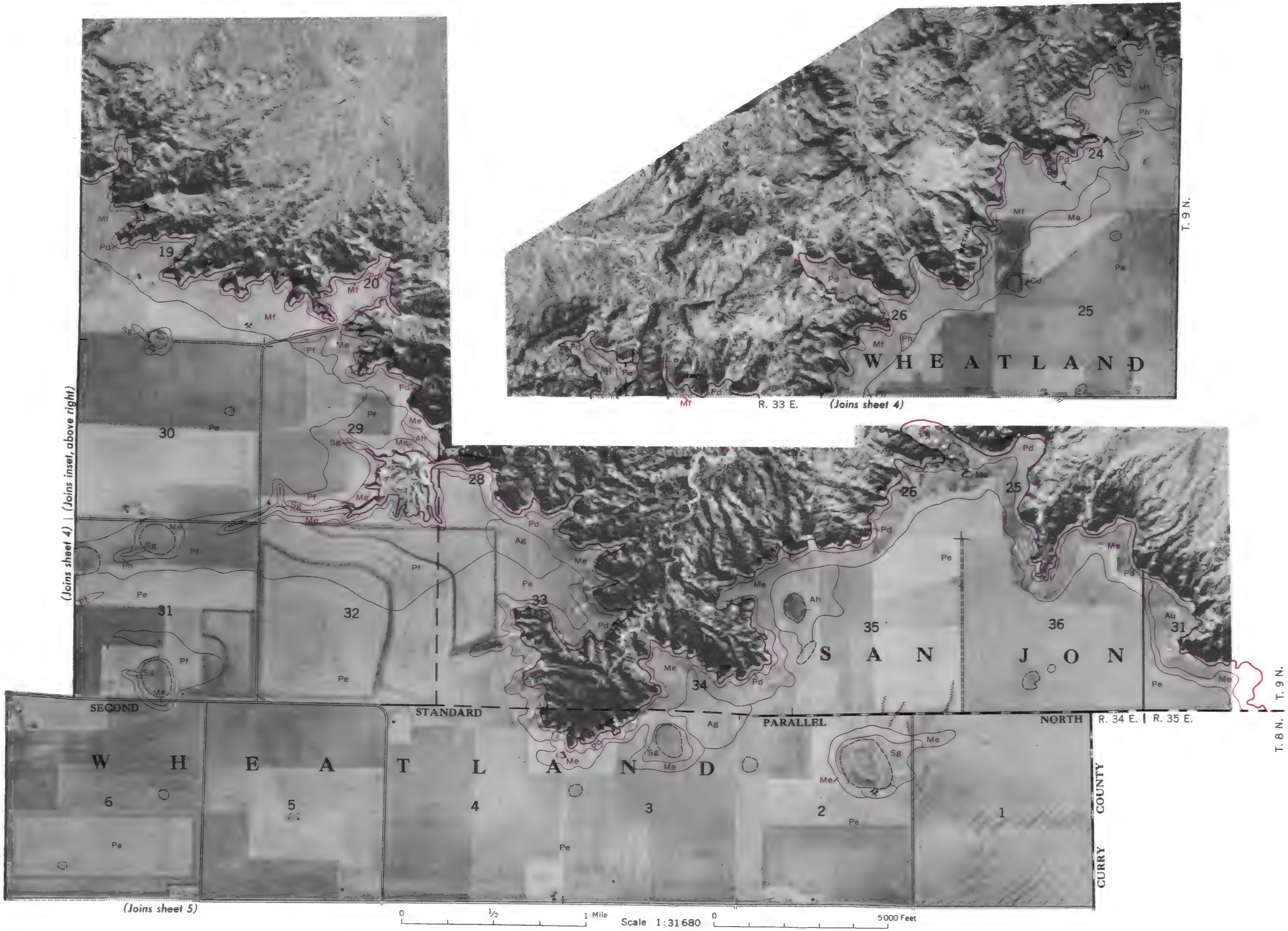
SOUTHWESTERN QUAY COUNTY, NEW MEXICO SHEET NUMBER 2



R. 27 E.

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N

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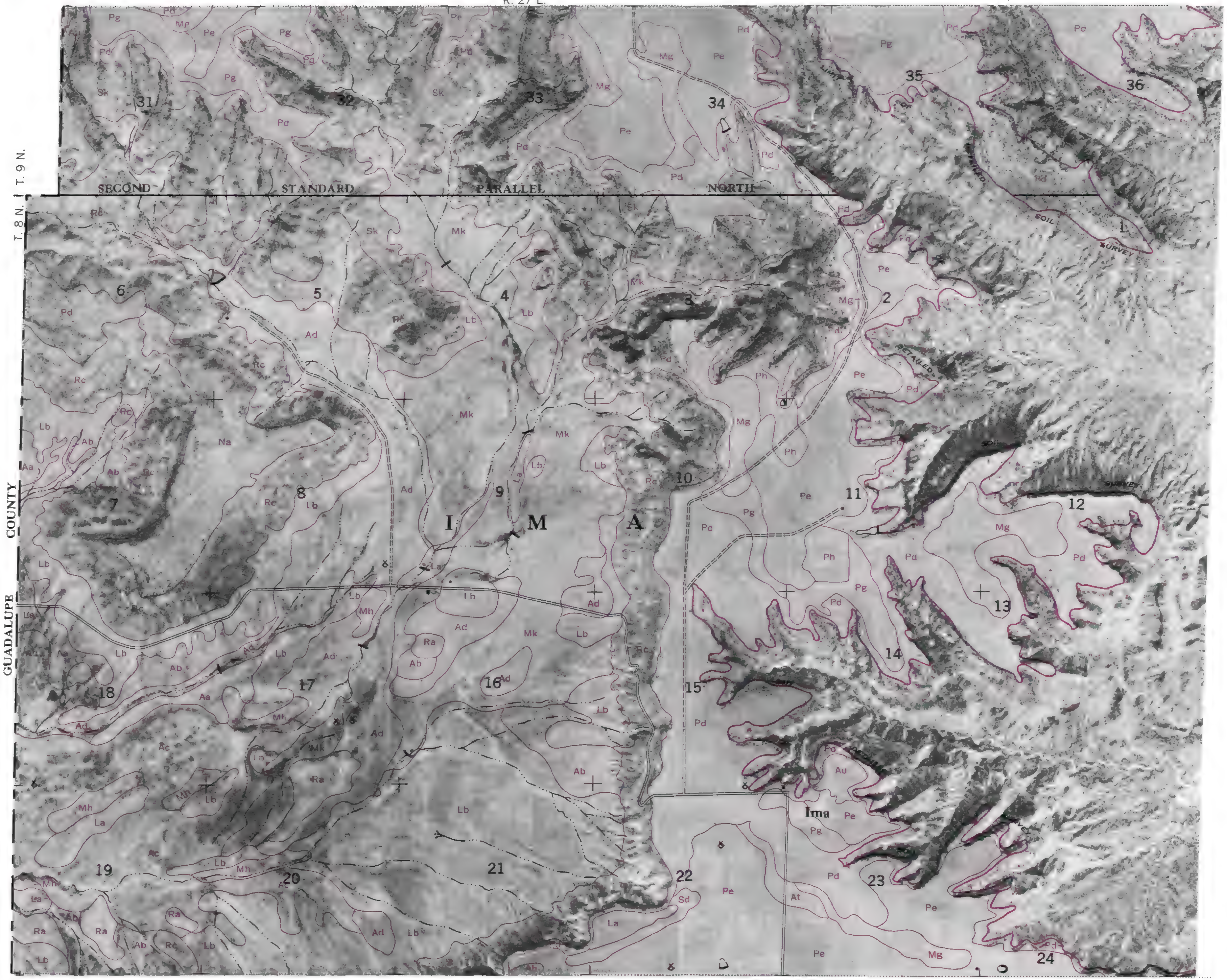
T. 9 N.

T. 8 N.

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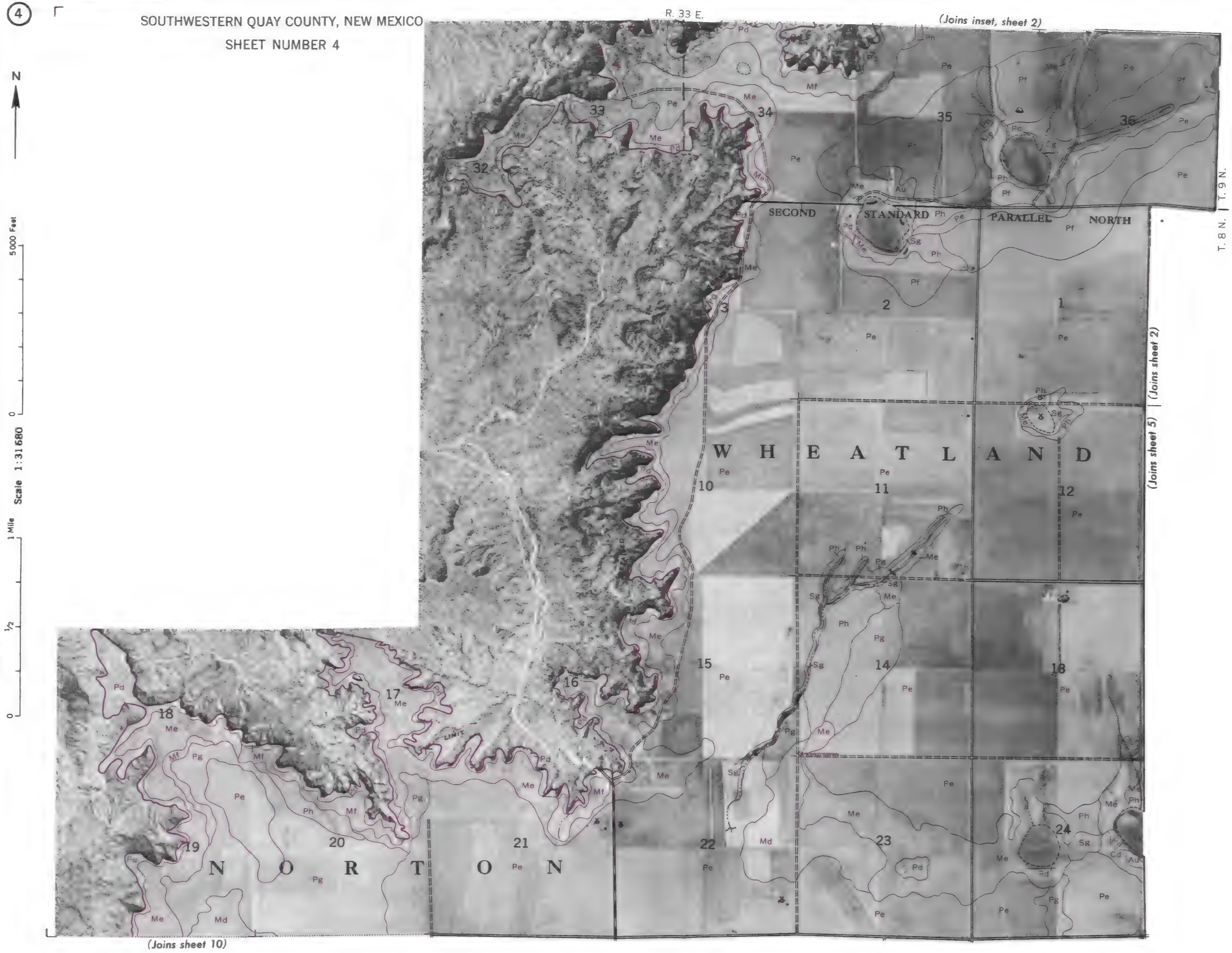
SOUTHWESTERN QUAY COUNTY, NEW MEXICO
SHEET NUMBER 4



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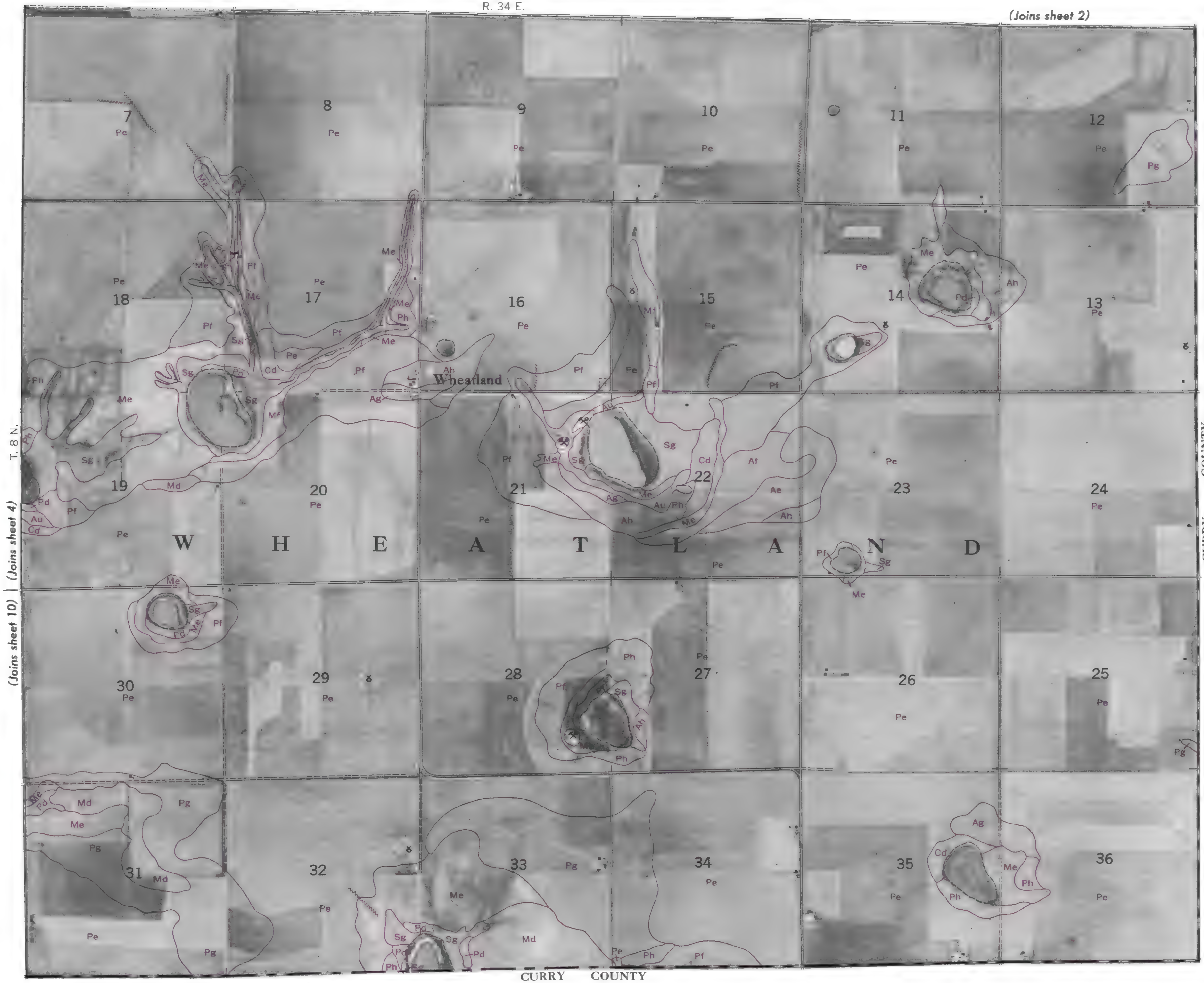


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(Joins sheet 3)
R. 27 E. | R. 28 E.
N
GUADALUPE COUNTY
T. 8 N. | T. 7 N.
(Joins sheet 7)
QUAY
IMA
ORTON
(Joins sheet 11)
0
1/2
1 Mile
Scale 1:31 680
0
5000 Feet

R. 28 E. | R. 29 E.



N

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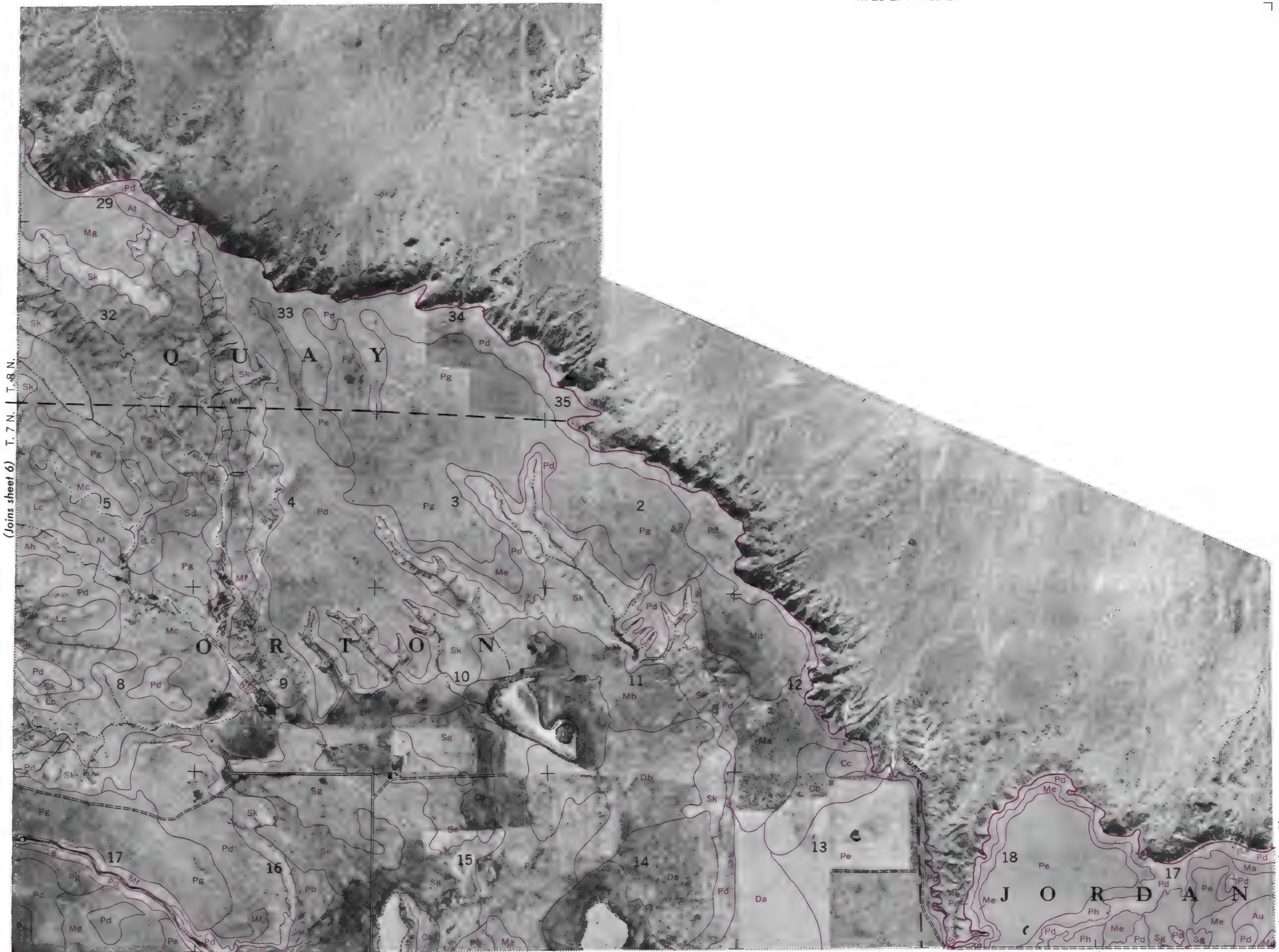
(Joins sheet 6)

T. 8 N. | T. 7 N.

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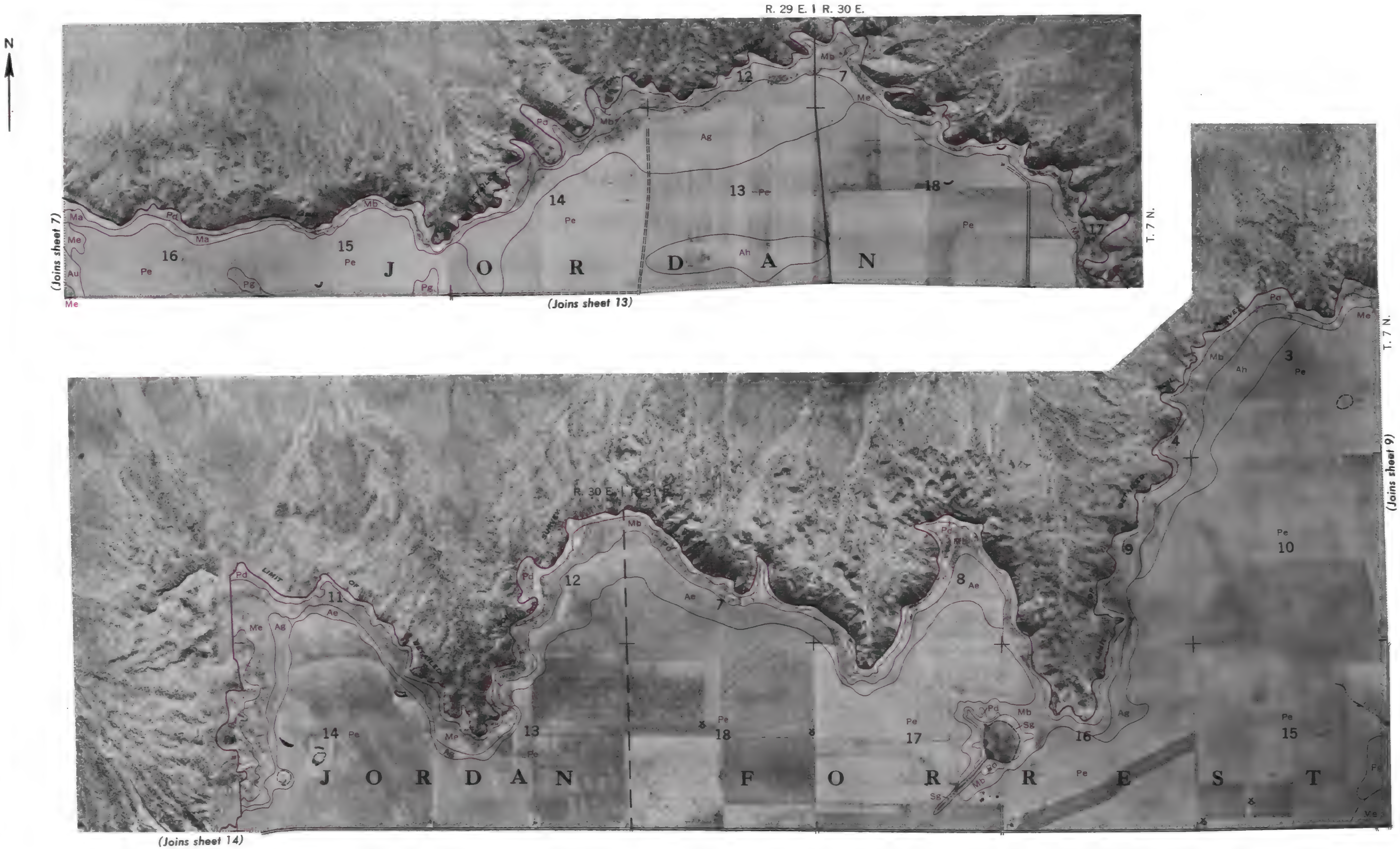
8

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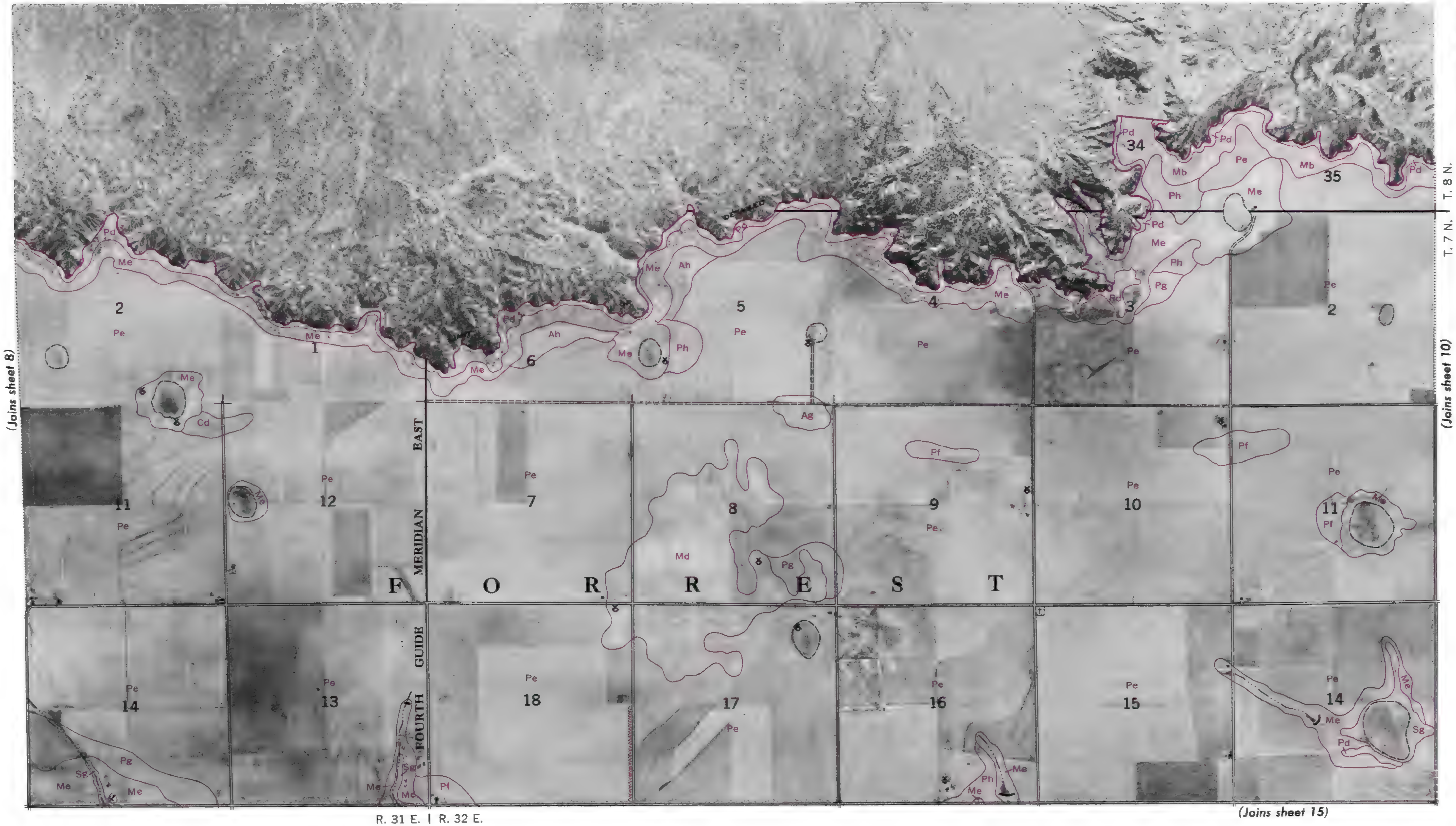


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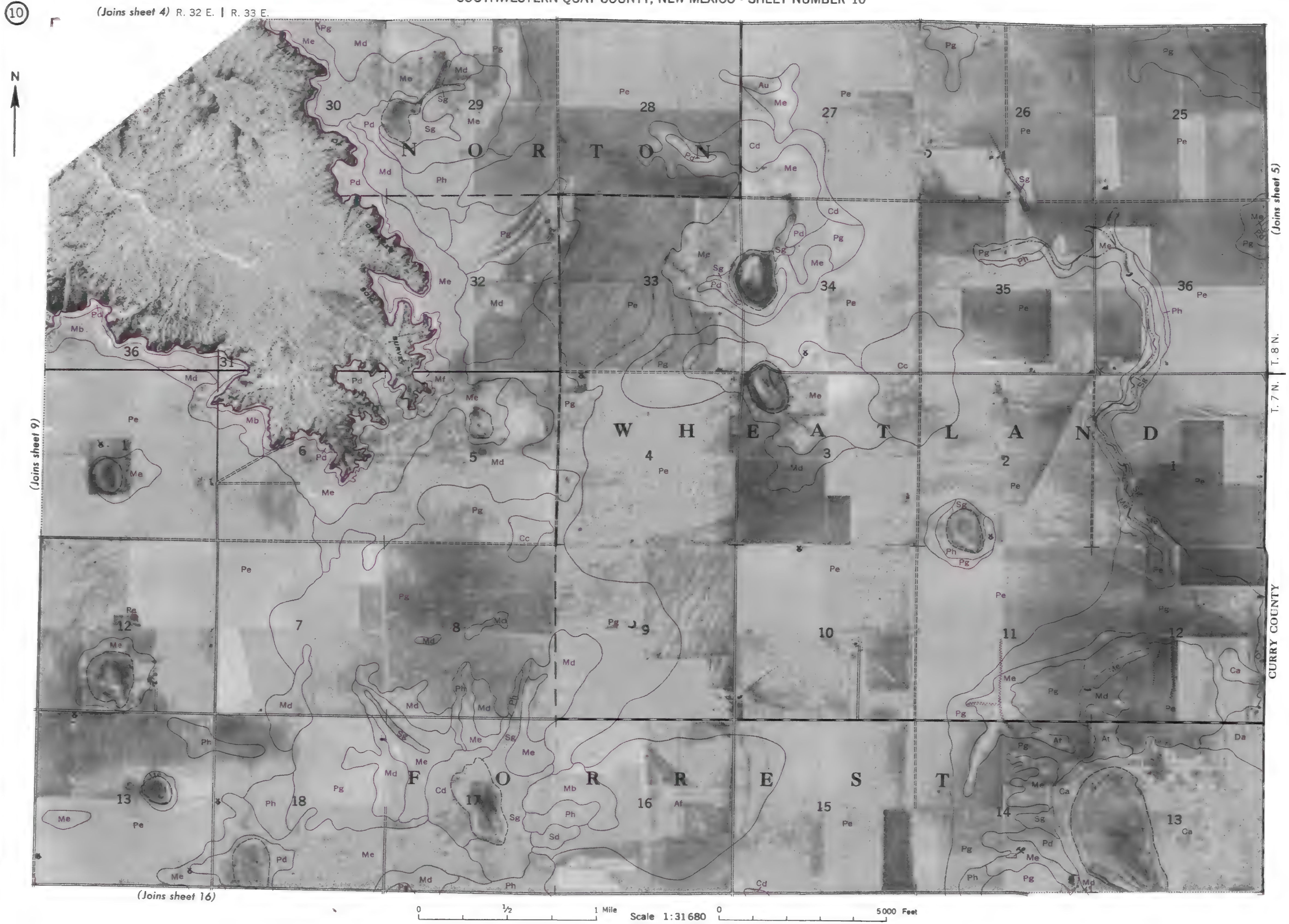
10
(Joins sheet 4)
R. 32 E.
R. 33 E.
N
(Joins sheet 5)
(Joins sheet 9)
(Joins sheet 16)
T. 8 N.
T. 7 N.
CURRY COUNTY
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W H E A T L A N D
F O R R E S T
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Scale 1:31680
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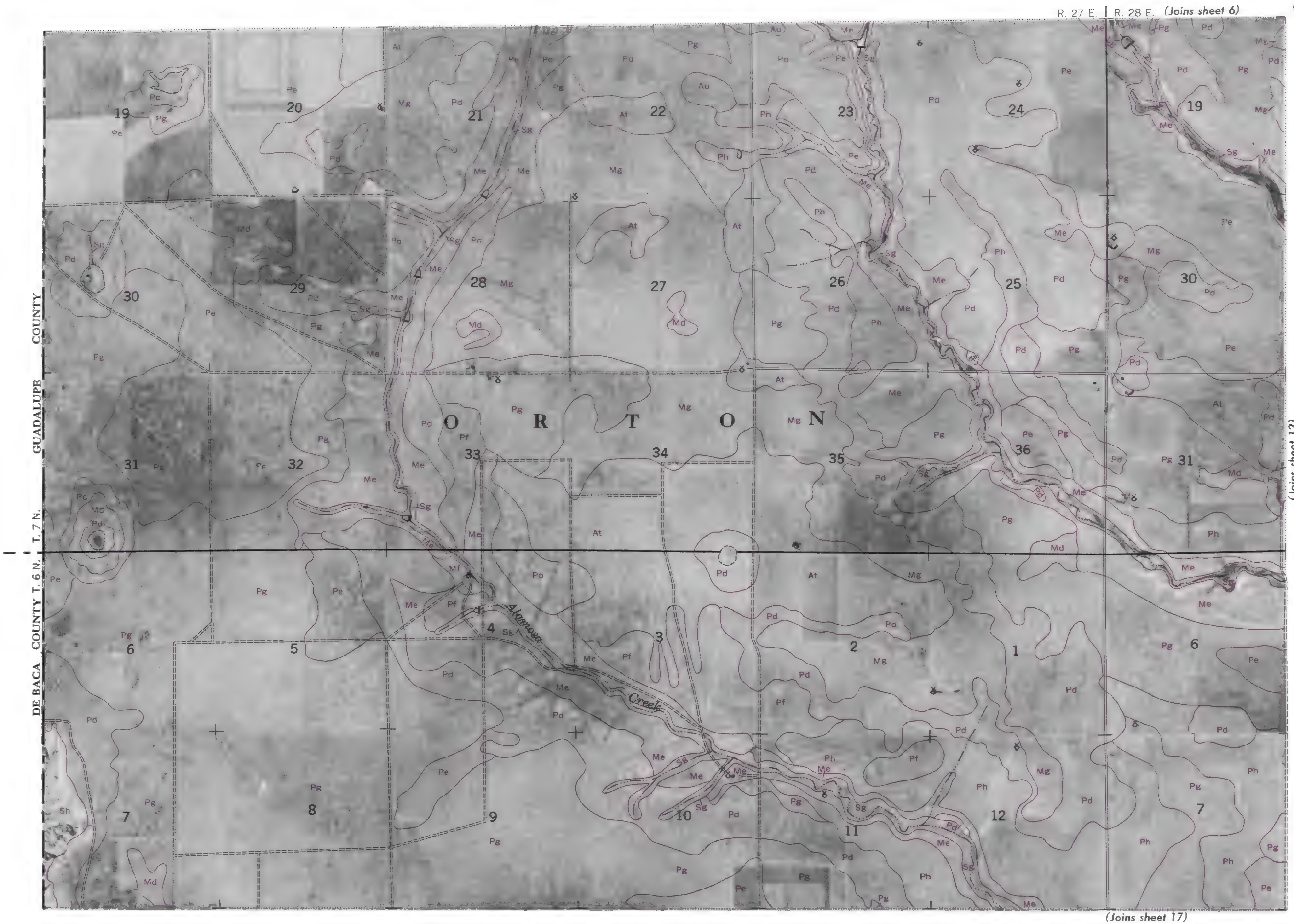
5000 Feet

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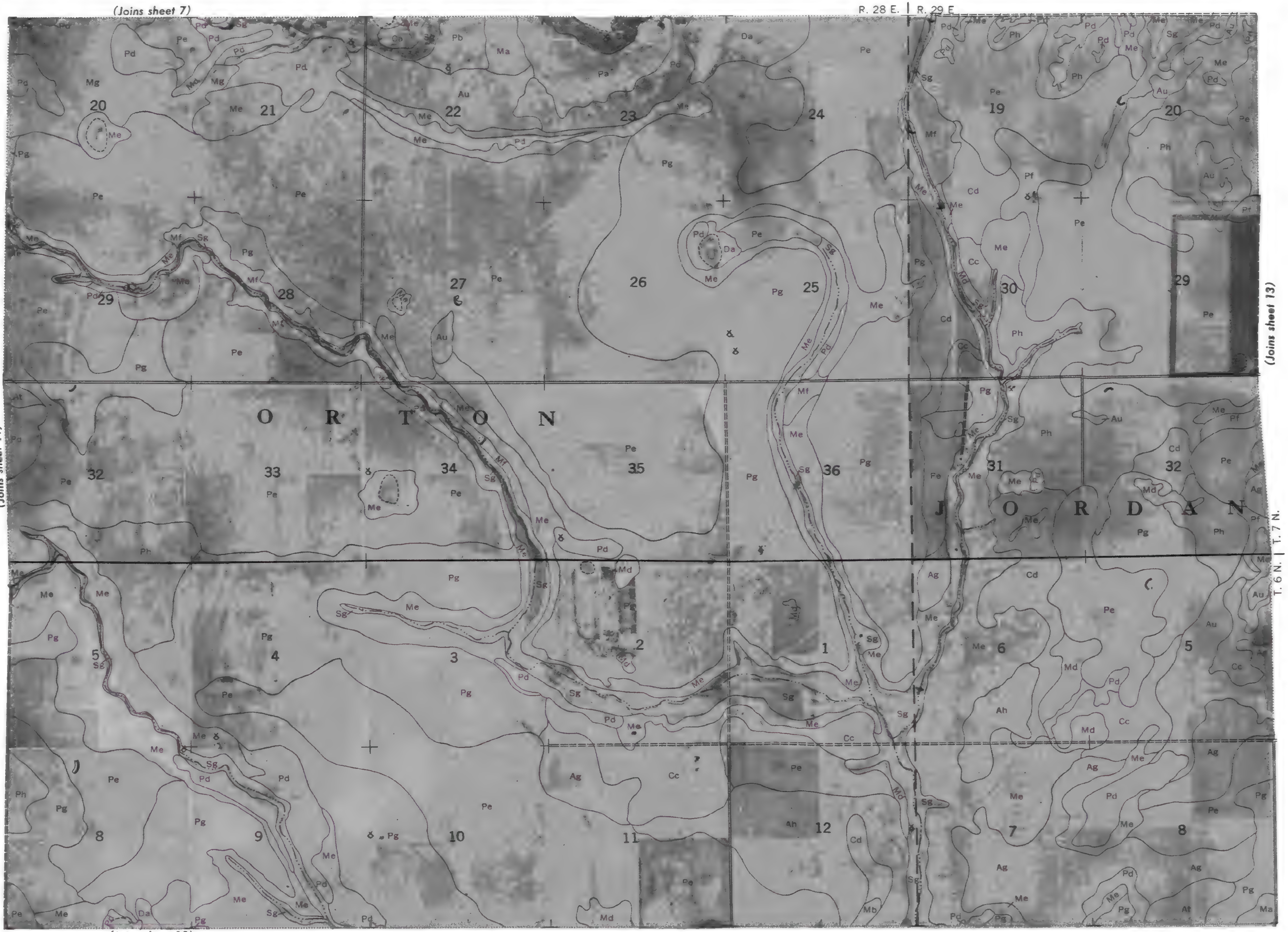
SOUTHWESTERN QUAY COUNTY, NEW MEXICO - SHEET NUMBER 12

12

(Joins sheet 7)

(Joins sheet 11)

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# SOUTHWESTERN QUAY COUNTY, NEW MEXICO - SHEET NUMBER 13

13


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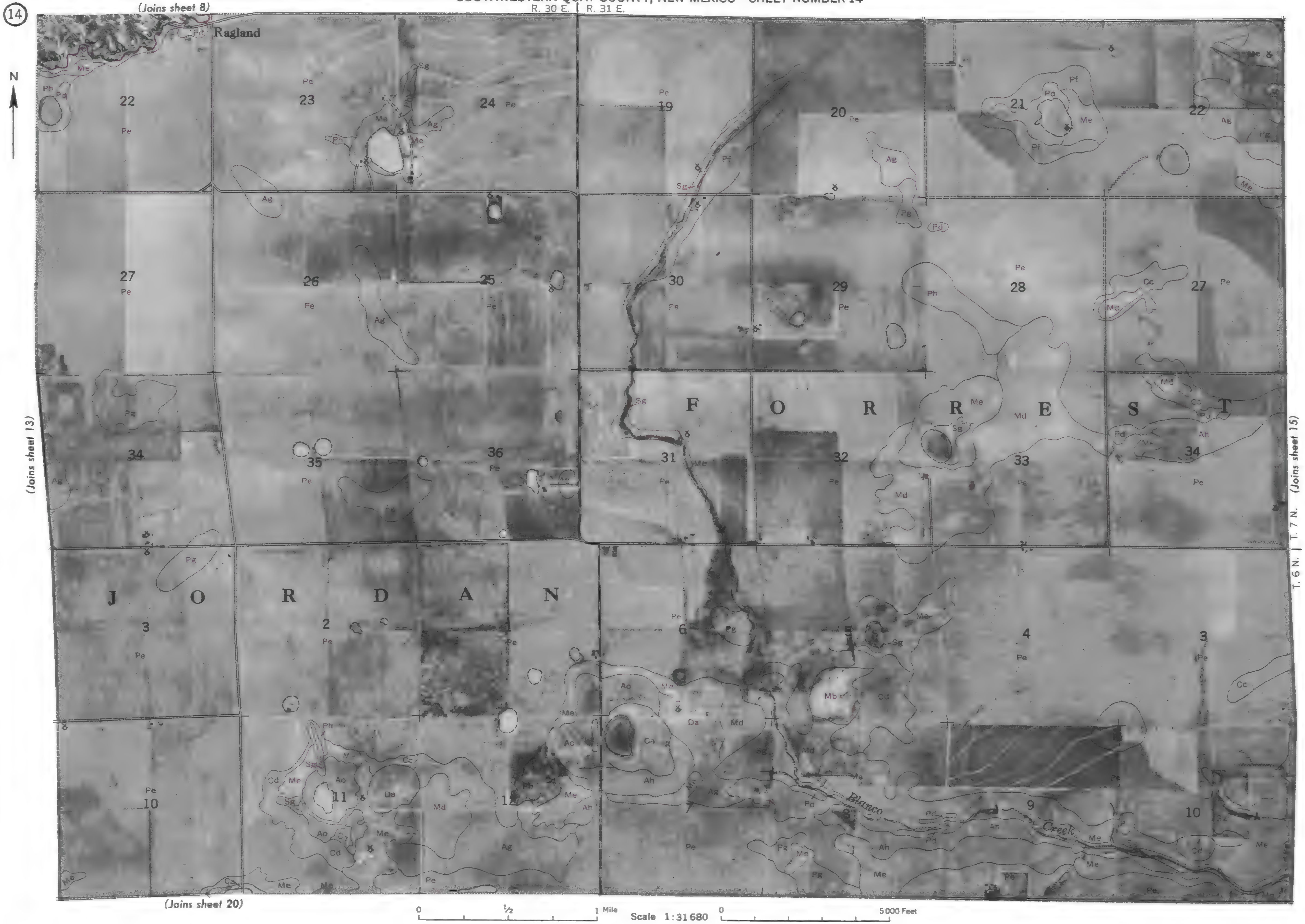
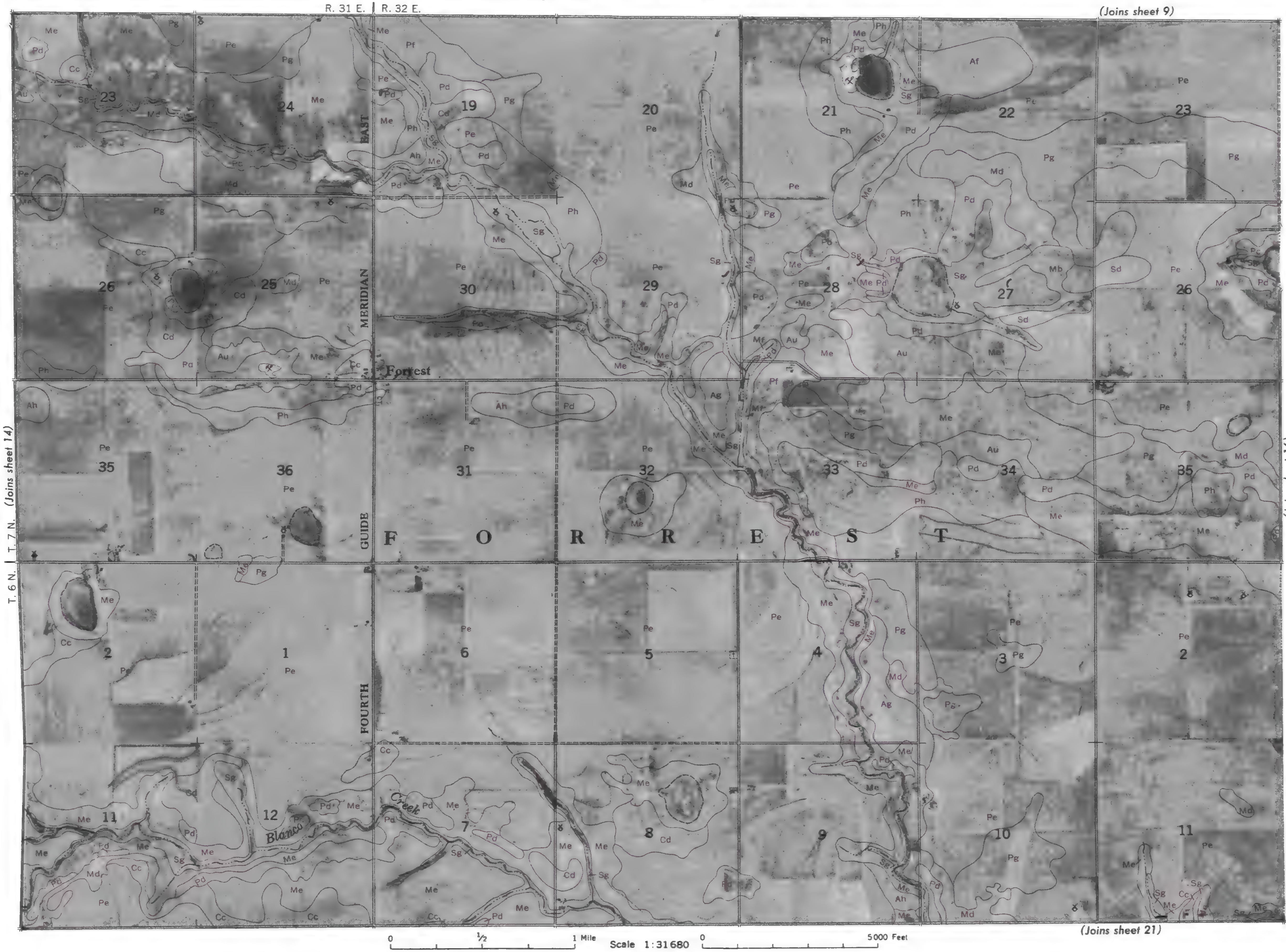


# SOUTHWESTERN QUAY COUNTY, NEW MEXICO - SHEET NUMBER 15



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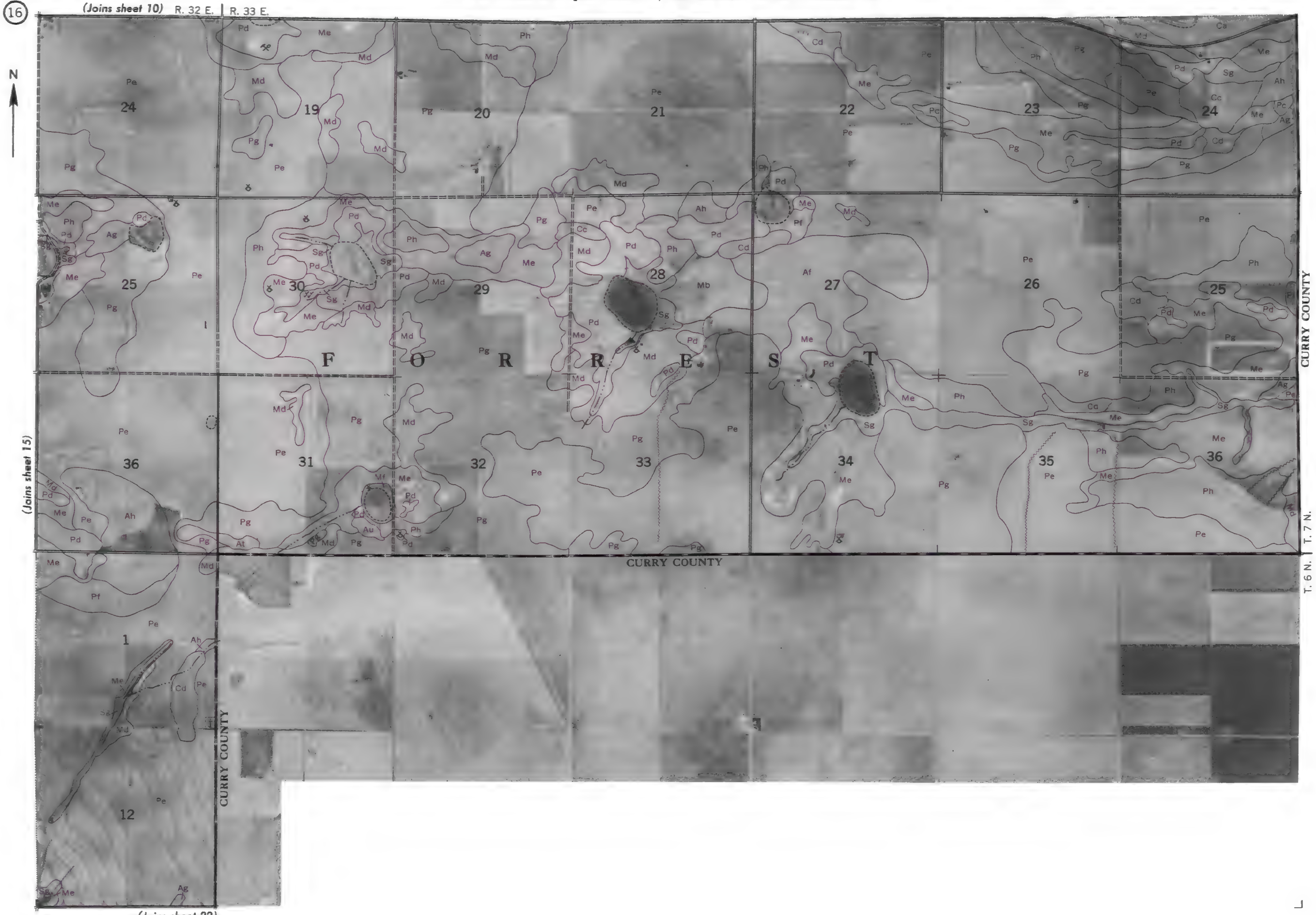


0 ½ 1 Mile Scale 1:31 680 0 5000 Feet

R. 27 E. | R. 28 E. (Joins sheet 11)

17

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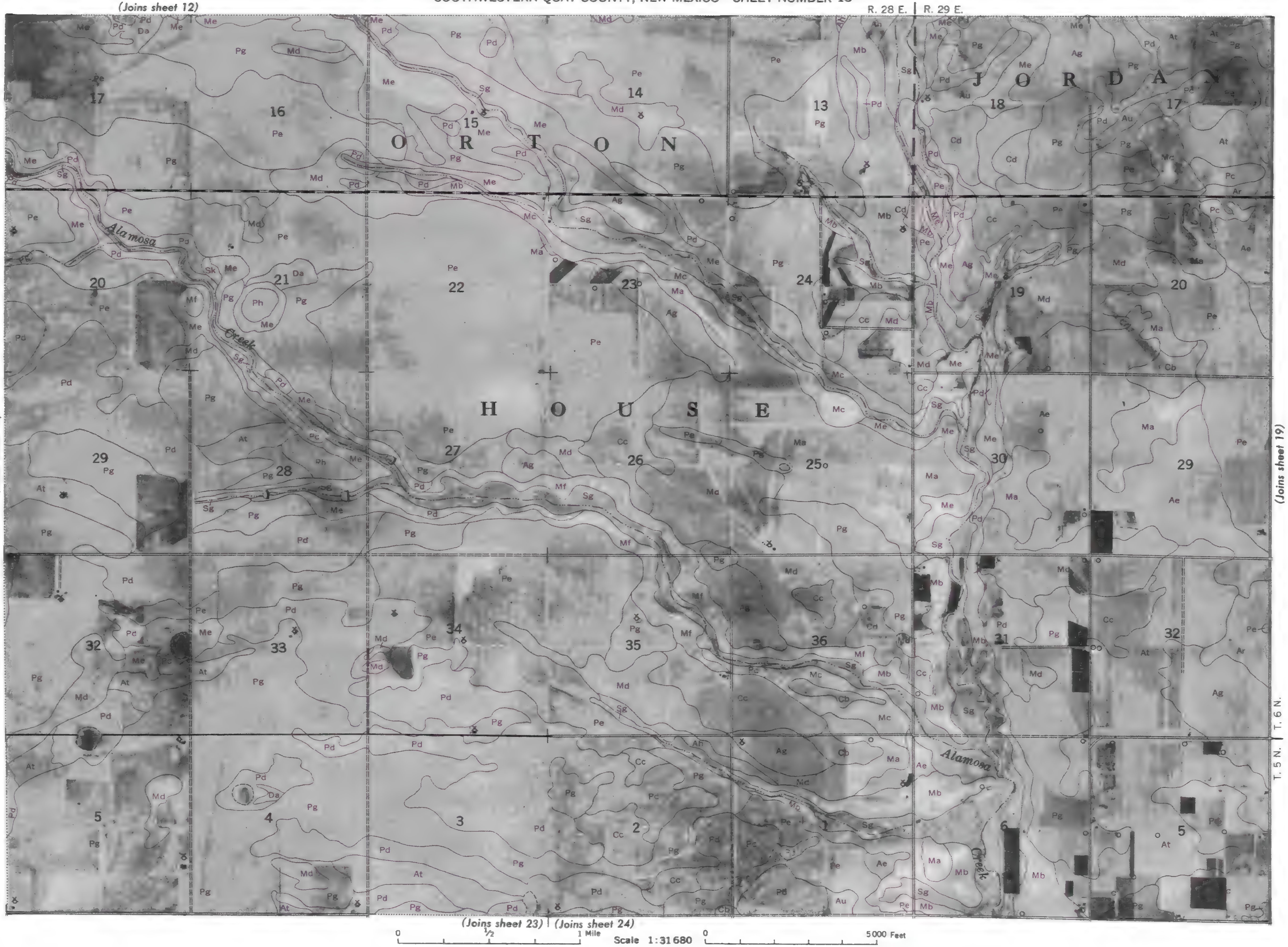
0 1/2 1 Mile Scale 1:31680 0 5000 Feet

SOUTHWESTERN QUAY COUNTY, NEW MEXICO - SHEET NUMBER 18



(Joins sheet 13)

19


(Joins sheet 18)

(Joins sheet 20)

(Joins sheet 24) | (Joins sheet 25)

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Scale 1:31 680

0 ½ 1 Mile

0 5000 Feet

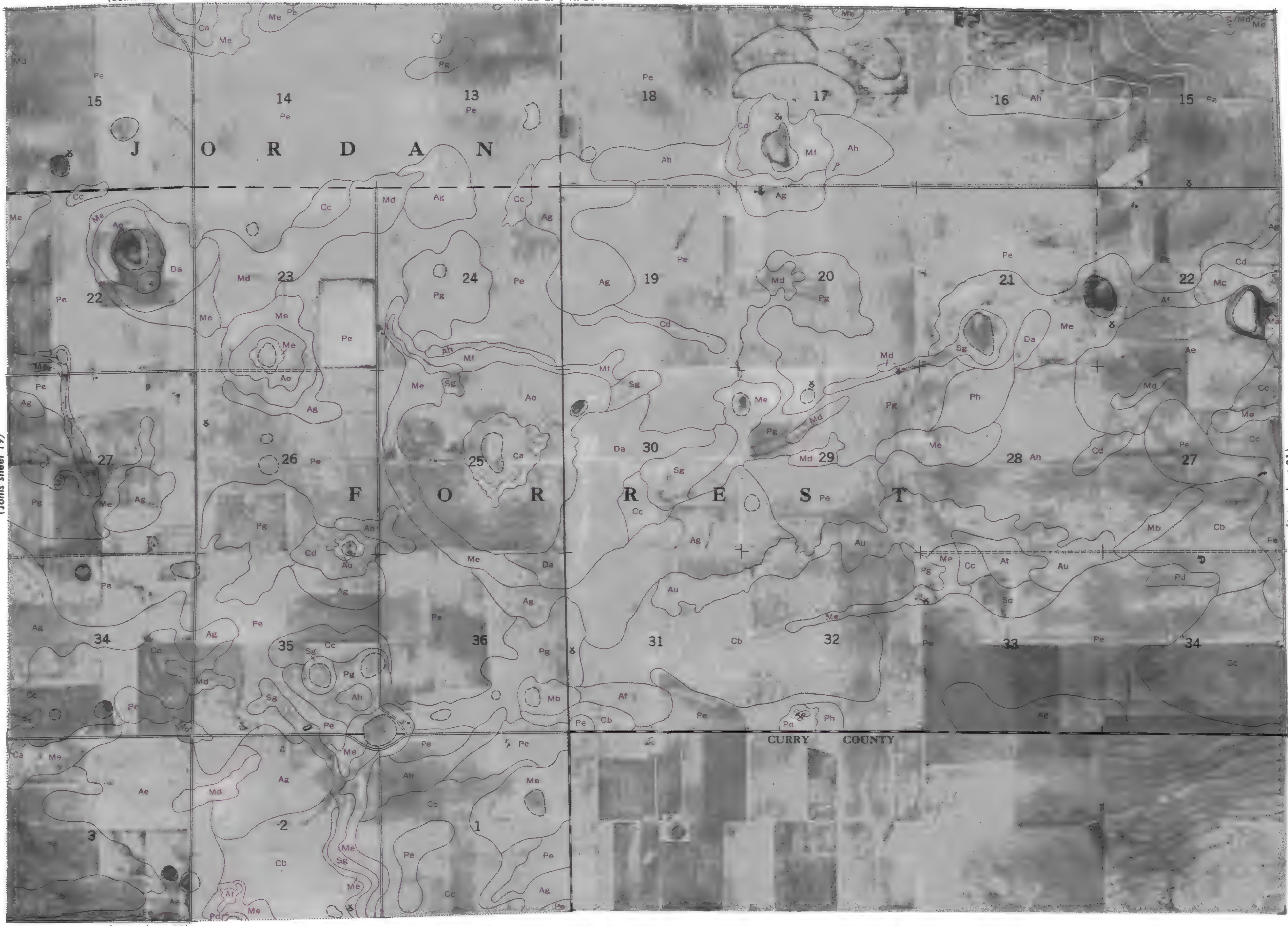
SOUTHWESTERN QUAY COUNTY, NEW MEXICO - SHEET NUMBER 20

(Joins sheet 14)

R. 30 E. | R. 31 E.

N

(Joins sheet 19)




(Joins sheet 21)

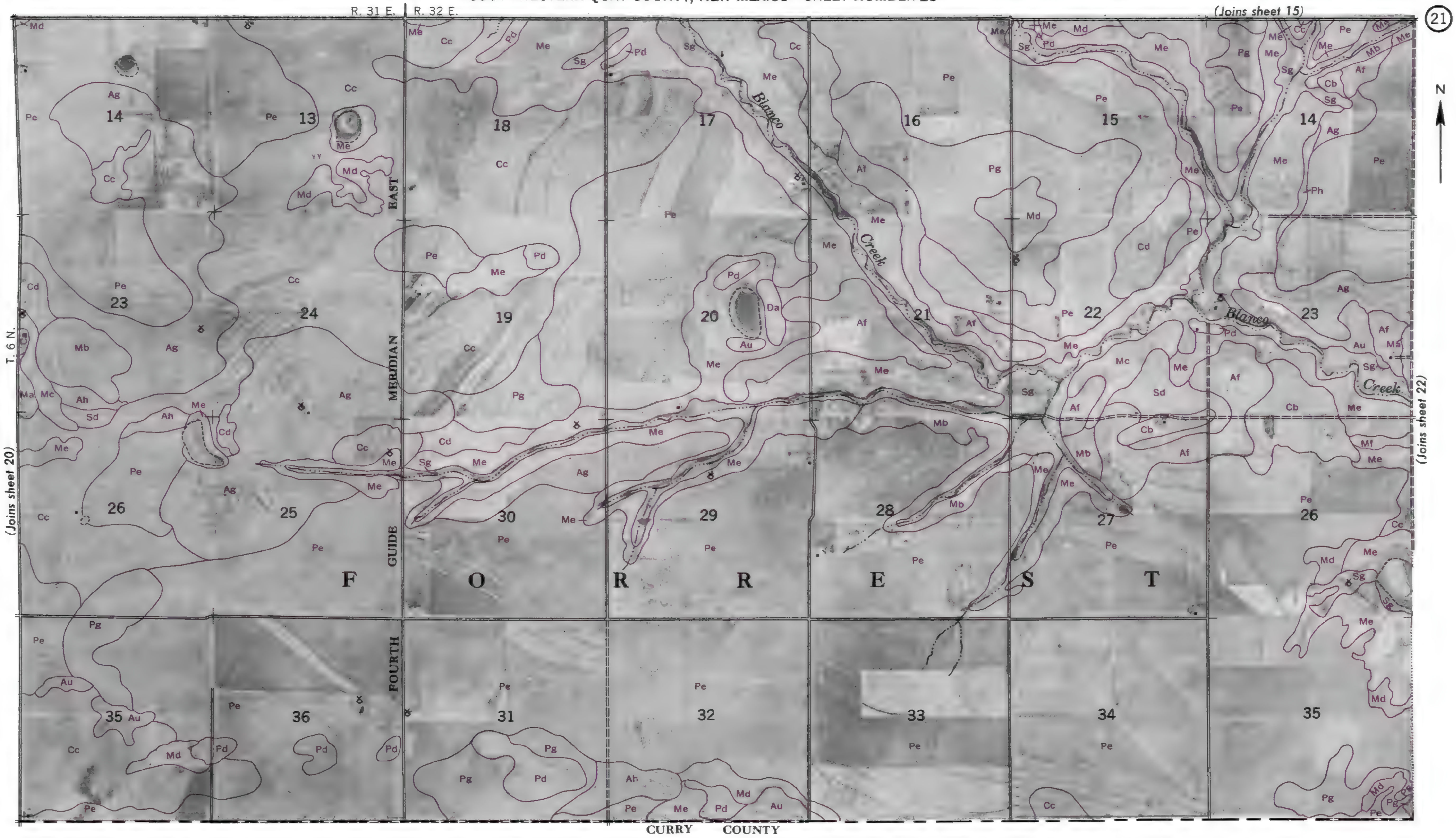
T. 6 N.
T. 5 N.

(Joins sheet 25)

0 ½ 1 Mile

Scale 1:31 680

0 5000 Feet

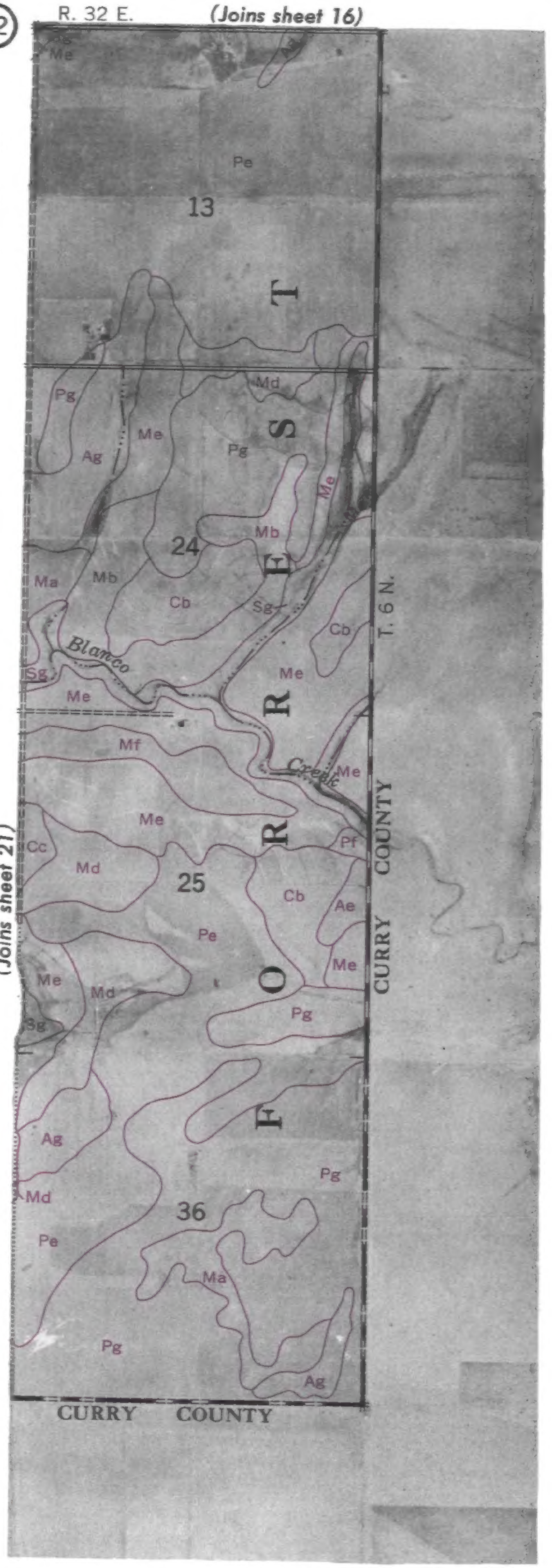


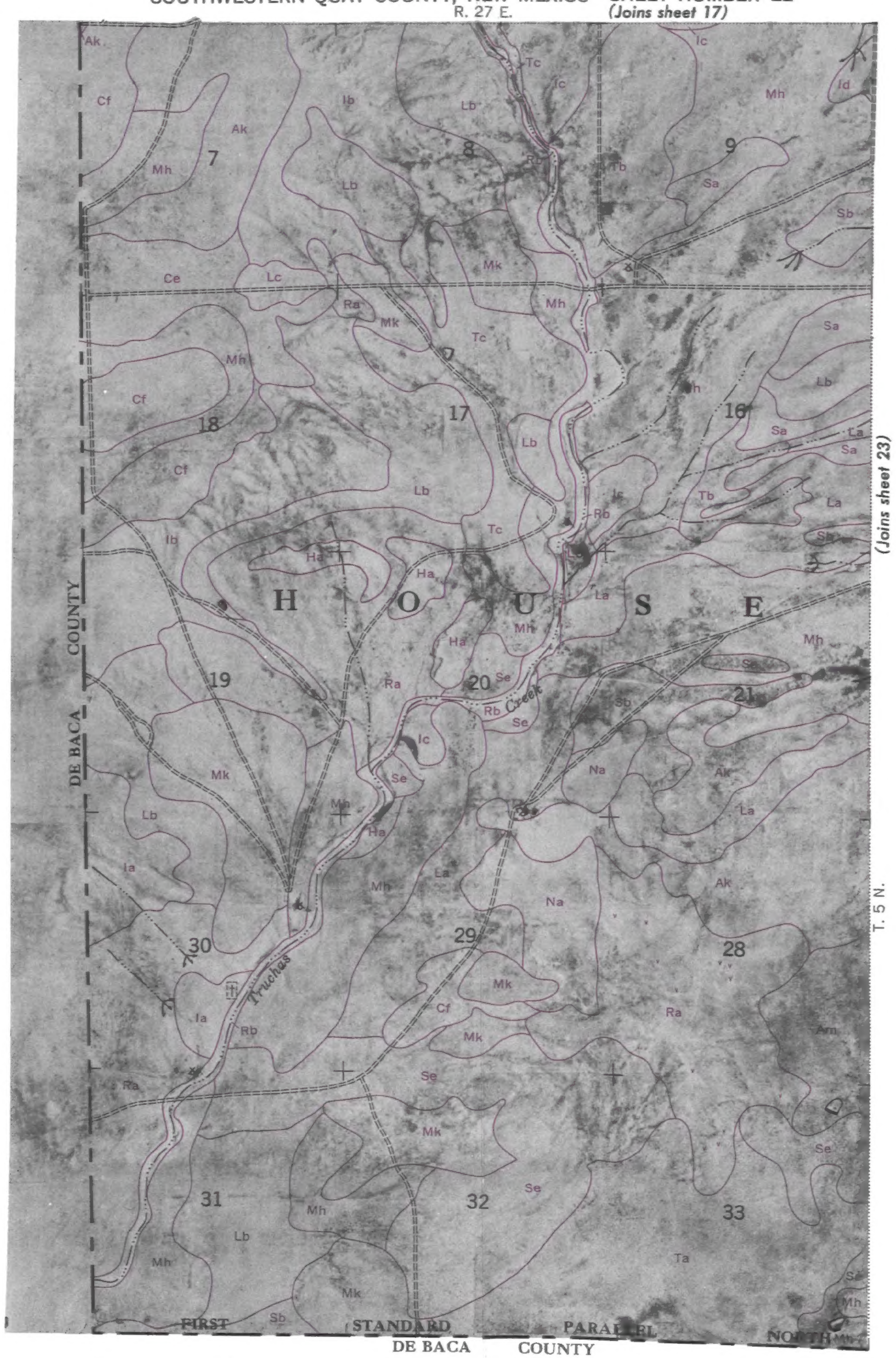

0 ½ 1 Mile Scale 1:31 680 0 5000 Feet

This is one of a set of maps prepared by the Soil Conservation Service, U. S. Department of Agriculture, for a soil survey report of this area. For information regarding the complete soil survey report, write the Soil Conservation Service, U. S. Department of Agriculture, Washington 25, D. C. This map compiled from aerial photographs flown in 1952.

Range, township, and section corners shown on this map are indefinite.

SOUTHWESTERN QUAY COUNTY, NEW MEXICO - SHEET NUMBER 22

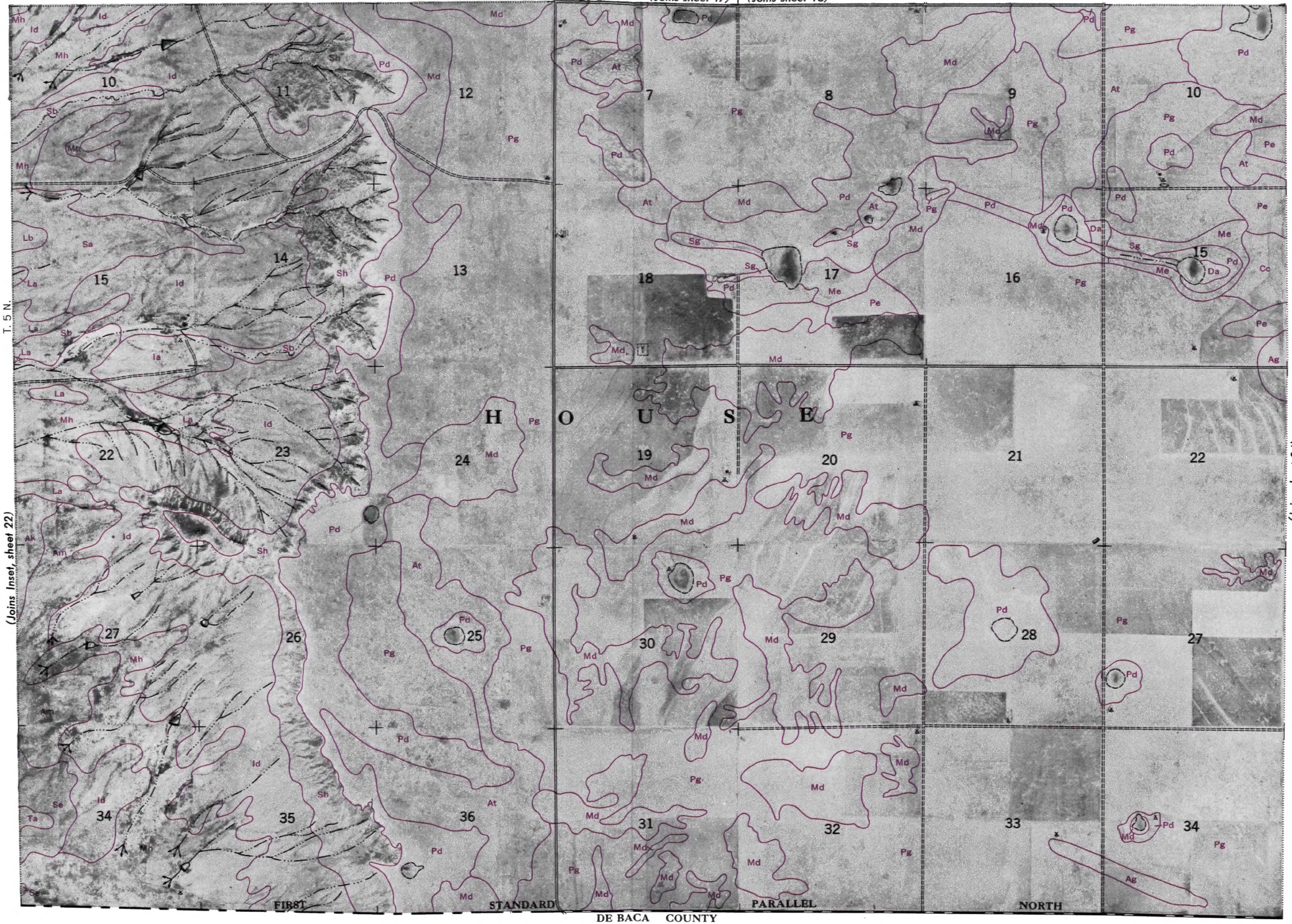



Scale 1:31 680 — 0, 1/2, 1 Mile — 0, 5000 Feet

SOUTHWESTERN QUAY COUNTY, NEW MEXICO SHEET NUMBER 23

23




Scale 1:31 680

0 ½ 1 Mile

0 5000 Feet

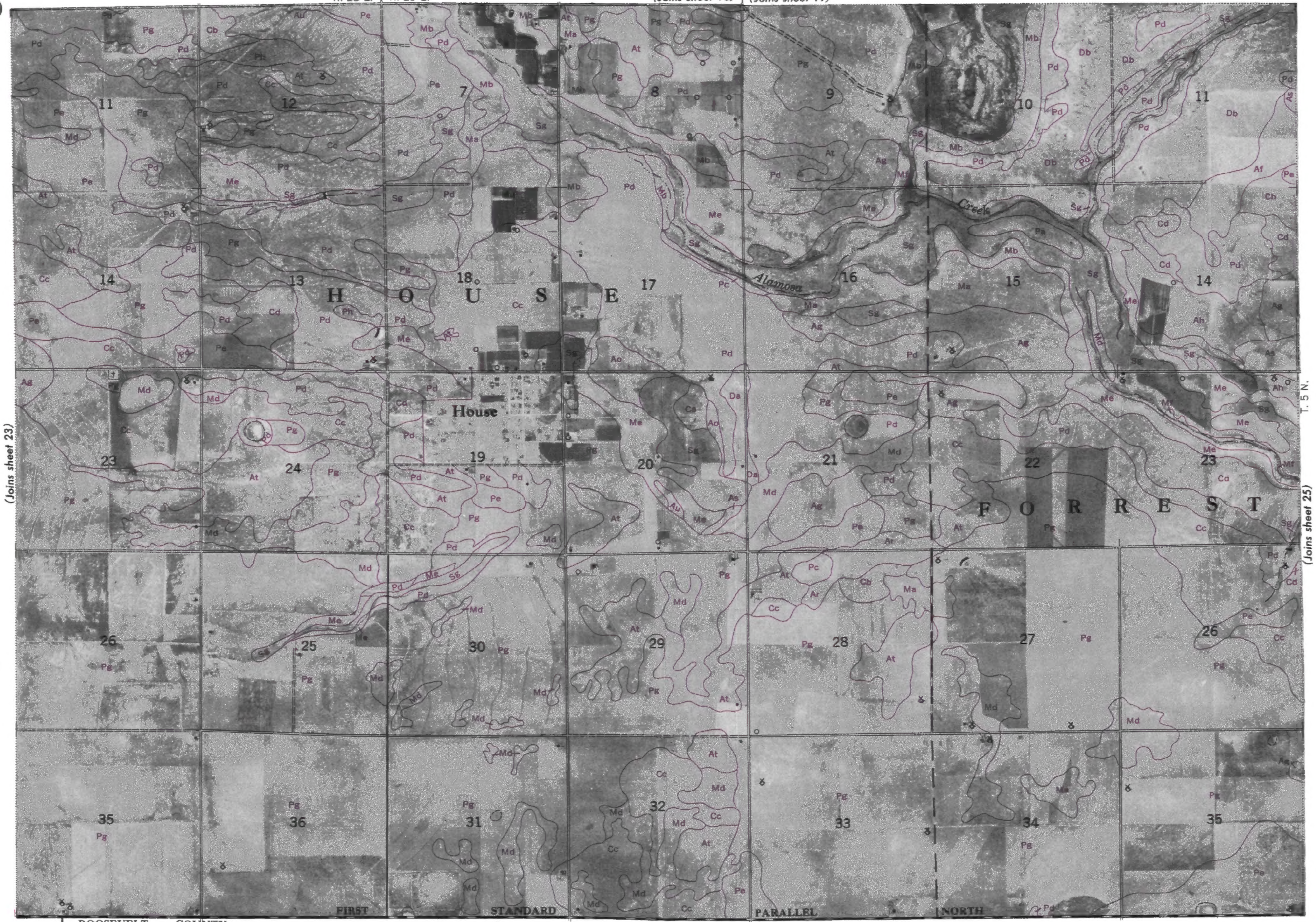
This is one of a set of maps prepared by the Soil Conservation Service, U. S. Department of Agriculture, for a soil survey report of this area. For information regarding the complete soil survey report, write the Soil Conservation Service, U. S. Department of Agriculture, Washington 25, D. C. This map compiled from aerial photographs flown in 1952.

Range, township, and section corners shown on this map are indefinite.

(24)

# SOUTHWESTERN QUAY COUNTY, NEW MEXICO - SHEET NUMBER 24

R. 28 E. | R. 29 E. (Joins sheet 18) | (Joins sheet 19)

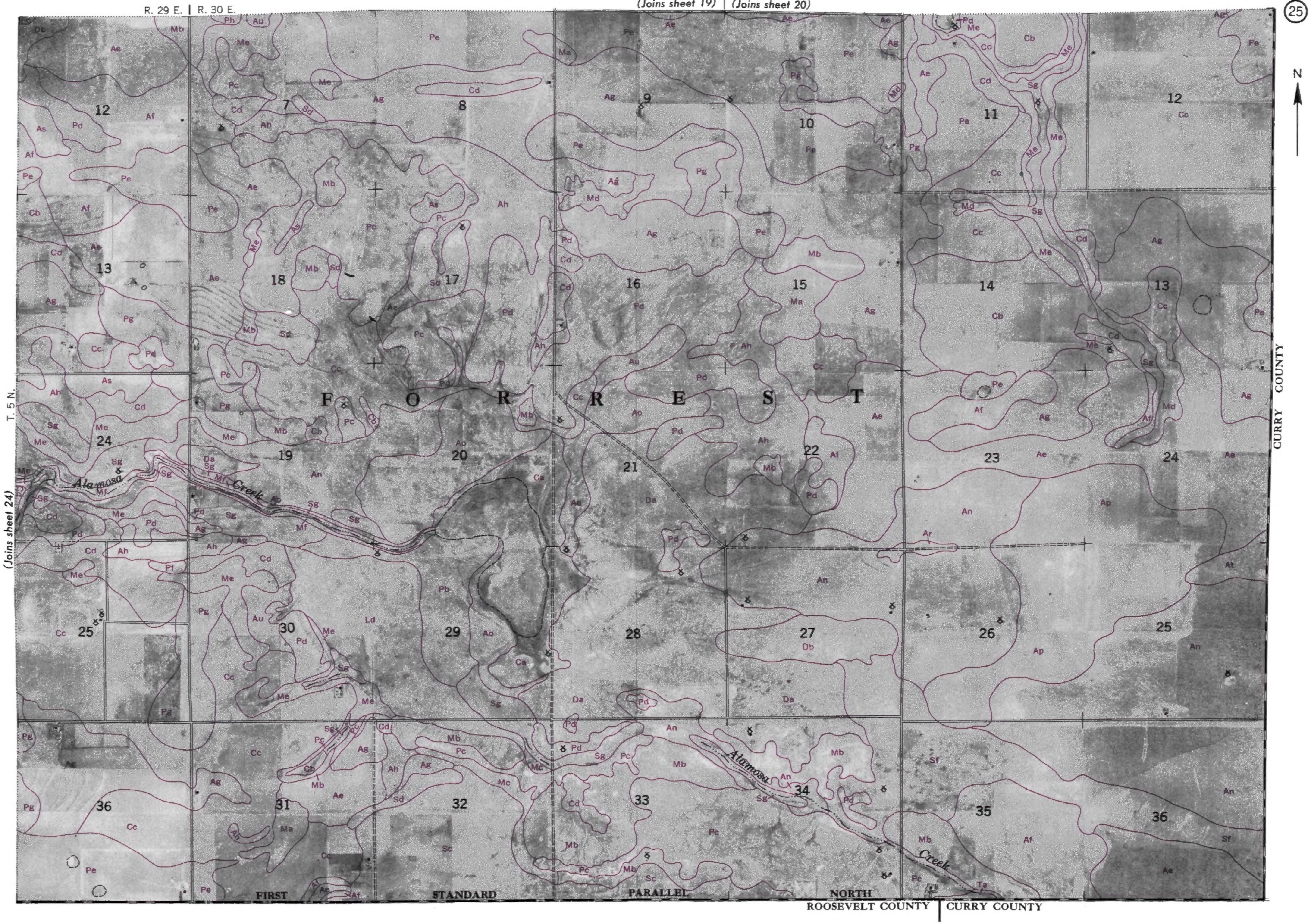



ROOSEVELT COUNTY

0 ½ 1 Mile Scale 1:31 680 0 5000 Feet

SOUTHWESTERN QUAY COUNTY, NEW MEXICO - SHEET NUMBER 25

(Joins sheet 19) | (Joins sheet 20)




This is one of a set of maps prepared by the Soil Conservation Service, U. S. Department of Agriculture, for a soil survey report of this area. For information regarding the complete soil survey report, write the Soil Conservation Service, U. S. Department of Agriculture, Washington 25, D. C. This map compiled from aerial photographs flown in 1952.

Range, township, and section corners shown on this map are indefinite.

Scale 1:31 680

0 — 1/2 — 1 Mile

0 — 5000 Feet